

УДК 612.014.426:613.648

### INFLUENCE MECHANISM OF THE NATURAL AND TECHNOGENIC ELECTROMAGNETIC FIELDS ON LIFE SAFETY

M.N. Tikhonov<sup>1</sup>, V.V. Dovgusha<sup>2</sup>, L.V. Dovgusha<sup>3</sup>

<sup>1</sup> International club of scientists, Russia, 191040 St. Petersburg, Ligovsky pr., 44

<sup>2</sup> Research Institute of Industrial and Marine Medicine of the Federal Office of Biomedical and Extreme, Russia, St. Petersburg, Yuri Gagarin Pr., 65

<sup>3</sup> State Budgetary Educational Institution of Higher Professional Education Northwestern State Medical University named after I.I. Mechnikov, Russia, 191015 St. Petersburg, Kirochnaya, 41

---

*The publication discusses the issues of medico-environmental effects of scientific and technological progress in the field of electromagnetic radiation (EMR) in three areas: man-made press EMR, electromagnetic factor in the etiology of diseases, the mechanism of the effect of electromagnetic radiation.*

**Key words:** *electromagnetic field (EMF), electromagnetic environment, EMF of extremely low frequency (ELF), modulated ultrahigh-frequency (UHF) fields, microwave radiation, radio wave sickness, power density, protection against EMR.*

---

*The impact of electromagnetic fields on human health as an industrial and environmental factor is an important issue that remains of current interest as the progress develops*

*Academician*

The medical and hygienic significance of natural and technology-related electromagnetic fields (EMF) attracts the attention of many researchers. The life of humans as a biological species throughout its evolution has been developing in the conditions of a natural electromagnetic background.

Electromagnetic radiation (EMR) includes radiation of any frequency scale starting from zero frequency and including electrotechnical and radio-frequency ranges, infrared radiation, visible light,

UV-band, R-rays,  $\alpha$ -radiation and cosmic radiation (see Table 1).

According to the scientific and medical literature, EMF includes EMR in the 0 to 300 GHz range – the so-called non-ionizing electromagnetic radiation of the electrotechnical and radio-frequency range which is the subject of our research. Natural EMF and their variants provide continuous interaction of an organism with the surrounding environment (SE), form the main biological rhythms of an organism, and contain information about the changes in the external environment.

---

**Mikhail Nikolaevich Tikhonov** – Specialist in the Interdisciplinary Expert Certification, Scientific-Technical and Control Centre of Nuclear and Radiation Safety (RESCentre) (LLC “RESCentre”, St. Petersburg), Academician of the International Academy of Ecology, Man and Nature Protection Sciences (MANEB) (e-mail: [dtrec@peterlink.ru](mailto:dtrec@peterlink.ru); tel. +7 (812) 233-58-06, +7 (812) 233-69-39).

**Dovgusha Vitaly Vasilyevich** – RANS Academician, Professor, Doctor of Medicine, Director of the Institute of Industrial and Marine Medicine, scientific consultant in CJSC “ATOM - MED CENTRE” Moscow-Saint Petersburg, Prize Winner of the Government Award in Science and Technology 2010 (e-mail: [vit130144@yandex.ru](mailto:vit130144@yandex.ru); tel. +7 (812) 727-48-60).

**Dovgusha Lilia Vitalyevna** – Candidate of Medicine, Therapist, occupational Pathologist of the highest qualification category, Assistant of the Department of Occupational Medicine in SBEI HPE “NWSMU named after I.I. Mechnikov” (State Budgetary Educational Institution of Higher Professional Education Northwestern State Medical University named after I.I. Mechnikov, Saint-Petersburg) (e-mail: [vit130144@yandex.ru](mailto:vit130144@yandex.ru); tel. 8 (812) 303-50-00).

Table 1

### The Electromagnetic Spectrum

Non-ionizing radiation						Ionizing radiation
Frequency, Hz	1-10 <sup>4</sup>	10 <sup>4</sup> -10 <sup>12</sup>	10 <sup>12</sup> -10 <sup>14</sup>	3,8·10 <sup>14</sup> 7,5·10 <sup>14</sup>	10 <sup>14</sup> -10 <sup>17</sup>	10 <sup>17</sup> -10 <sup>21</sup>
Wave length	>10 km	10 km – 0.1 mm	0.78 μm – 1 mm	0.78 μm – 0.38 μm	400 nm – 10 nm	10 nm – 10 pm
Low-frequency vibrations (including EMR of power current)		Radio waves	Infrared radiation	Visible light	Ultraviolet radiation	X-rays and Gamma-rays

A targeted use of electromagnetic (EM) energy in various industries has resulted in the fact that artificial electromagnetic field has been added to the current electric and magnetic fields of the Earth, atmospheric electricity, and radio waves of the Sun and the Galaxy. Its level significantly exceeds the strength of the natural EM background. Artificial EMF include the following: power lines, in-house electrical wiring, industrial and domestic electric plants, electric transport, PC and television receivers, radio transmitters and radar installations, radio and cellular telephones, microwaves and more. Multiple uses of EMR sources, introduction of new hardware that creates a powerful EMF have led to an increase in the scale and intensity of their effects on humans and the biosphere as a whole [2-4,8,12,21,22,33].

Suffice it to say that the energy resources of the world are doubling every 10 years, while the share of variable EMF in the power industry has increased three-fold over the same period. If 35-40

years ago the issue of bioelectromagnetic compatibility affected only the cases of occupational exposure (mainly by radar stations and electrotechnological plants), today it is reasonable to talk about the threat of exposure to man-made EM-pattern of all the population of the planet no matter the age and exposure time.

With today's level of civilization (increased introduction of EM sources into everyday

life and a high biological activity of technology-related EMR), the EM characteristic of the surrounding environment has dramatically change in the last decade. A report by the Inter-departmental Commission of the RF Security Council on Environmental Safety № 2-2 of 20.02.1996 indicates that the impact of EMR on people and the environment is becoming extremely dangerous. The total strength of EMF at different points of the earth's surface exceeds the natural radiation background by 100-10000 times. In the last 50 years, the daily output of radio radiation has grown by more than 50 thousand times. This does not include the output of radio-location stations that belong to various military agencies. The strength of magnetic fields of industrial frequencies at the locations of air-tracks and extra-high voltage substations is by times higher as compared to the natural level of the planet's magnetic field. High levels of EMR are observed in the areas of location of radio transmission centers of low, average and high frequency. There are whole regions where the level of EMR exceeds the hygienic standards in terms of human exposure [2-4,8,10,21,22,33].

Today the Earth has large electromagnetic 'spots' created by mega-cities that have completely changes the geophysical appearance of the planet. As a result, the luminosity of the Earth in the radio range exceeds the luminosity of the Sun.

In 1926, Vladimir Vernadsky, the founder of the study of noosphere, noted that "around us,

inside us, everywhere, in everything, there is radiation of various wave length; it is alternating, coinciding, and colliding". As a matter of fact, the frequency spectrum of acoustic vibrations and EMR is very broad and includes the waves ranging from ultralow frequency ultrasound to ultrasonics, from low frequency radio waves to ionizing radiation (see Table 1).

Large cities today create areas with a high level of technology-related electromagnetic fields that have a complex dimensional, time and frequency structure; majority of the population reside here. Electric transport contributes significantly to the development of 'electromagnetic smog'. Magnetic fields generated by electric transport have a complex frequency structure; the majority of its components have a frequency below 15 Hz. Such fields are proved to carry a serious threat to human health [2-6, 8, 12].

There has been a lot of research on electromagnetic safety of work with video-display terminals [2]. However in recent years the level of electromagnetic radiation of PCs has been significantly decreased, so researchers have lost their interest in this topic. Non-ionizing radiation prevails in many industries; nevertheless, some researchers believe that we overestimate the significance of the level of electromagnetic fields at the workplace and underestimate its significance at home [3, 4, 35].

Cellular communications including transmitting radiotechnical stations (cell sites – CS) and mobile phones (MP) are significant sources of EMR in an urban environment.

The prevalence of electromagnetic emissions is explained by a significant growth in the number of EMR sources and its significant proximity to people which to the full extent characterizes cellular communications.

The number of cellphone users worldwide reaches 2.06 billion people, in Russia – over 115 million people.

One of the parameters of cellular communications that describes their hygienic significance as a health risk factor is the conditions of cell site locations, their amount in a service area, mobile phone characteristics, exposure factors and number of users.

In recent years, a lot of attention has been paid to hypomagnetic conditions. Isolation of man or animal from the surrounding electromagnetic background can lead to more drastic consequences than the impact of rather strong magnetic fields. In this regard, there is a curious report by Sergey A-

kyan et al [1] on mental and physical stress that would develop during radio communication between Salut-6 space station crew and Space Operations Center exactly in the time of disappearance of geomagnetic pulsations.

The analysis of the geomagnetic background in the days of aircraft accidents over the period of 1988-1998 showed that faulty actions of the crew take place, as a rule, in the time of increased geomagnetic activity. In contrast, equipment failure is usually related with decreased magnetic activity on the day of an accident [7].

Growing electromagnetic pollution of the environment in big cities is a cause of concern among hygienists and ecologists. Significant increase in the strength of EMF should be reviewed as a one-time event in terms of evolution – a huge leap with unpredictable (for the time being) biological consequences (see Table 2). "For the time being" should be considered from two positions. Protection of the genetic code of the living beings is currently coping with the growing electromagnetic technology-related smog. In the future, such a sharp (in terms of evolution) spike in the strength of EMF may result in the biological exhaustion of the genetic code as we know it.

Ultralow frequency (0-10 Hz) and very low frequency (10-1000 Hz) electromagnetic fields are generated during the operation of electric and railway transport, power lines, substations, and cable tracks. For example, the strength of electromagnetic fields in St. Petersburg is by 100-1000 times higher as compared to the natural background typical of suburbs [16, 17].

In St. Petersburg and Leningrad Region, the following entities are exposed to electromagnetic irradiation of hygienically significant levels, according to a preliminary assessment [13]:

- ☐ Approximately 30 % of the population engaged in jobs that involve production and use of electromagnetic energy (occupational exposure);
- ☐ Approximately 60 % of the St. Petersburg population exposed to non-occupational irradiation (residing in close proximity to overhead power transmission lines as well as in houses with electric stoves, PC users, cell phone users, etc.).

Characteristics of electromagnetic irradiation of the population in St. Petersburg [13] include:

Table 2

**Natural background and maximum permissible level (MPL) for the technology-related background in terms of EMF**

Indicator	Strength of the electric component, V/m			Power flow density,
	50 Hz	0,03 – 50 M Hz	50 – 300 M Hz	0,3 - 300 GHz
Maximum natural background	$10^{-5}$	$6,1 \cdot 10^{-8} - 10^{-5}$	$6,1 \cdot 10^{-8}$	$10^{-7}$
Technology-related background of EMR	$10^3$	$5,7 \cdot 10^{-3} - 3 \cdot 10^{-2}$	$6,3 \cdot 10^{-4}$	$10^{-3} - 0,83$
Exceeded natural background, times	$10^8$	$3 \cdot 10^4$	$10^4$	$8,3 \cdot 10^4$
MPL	5000	500	80	1000

☒ Dual nature of irradiation: electromagnetic background from multiple stationary sources (integral parameter) and EMF from point sources (differential parameter);

☒ High concentration of EMF sources and population per unit area which makes the analysis of electromagnetic irradiation difficult;

☒ High probability of continuous EMF exposure in a number of situations (24/7 and for several years in a row);

☒ Impact on a large number of people, including children, the elderly and the ill, including those with predisposition to cancer;

According to M.Rudakov [15], evaluation and prevention of EMR are complicated due to the following reasons:

- in the majority of cases, it is impossible to limit the emission of a contaminant into the environment;
- the replacement of this factor with a less harmful one is complicated;
- it is impossible to 'clear' the air off unwanted emissions;
- one of the characteristics of irradiation in an urban environment is its aggregate impact on the population (integral parameter) as well as individual impact from strong EMF from individual sources;
- the medico-hygienic approach aimed at limiting the EMF to the natural background level is unacceptable;
- we have here a continuous impact of the electro

magnetic field (24/7, for several years in a row) on large groups of people, including children, the elderly and the ill;

- it is difficult to statistically describe the parameters of radiation coming from scattered sources that operate in various modes.

The mechanism behind the biological effect of weak electromagnetic fields of both natural and technology-related origin on living being is still unclear. Nor there is an acknowledged theory. The situation is complicated by the fact that human senses do not perceive EMF fields in their entire frequency range except for the visible range; for this reason, it is impossible to evaluate the level of hazard presented by electromagnetic irradiation without using specialized equipment. Several decades is not long enough to study the impact of artificial EMF on biological objects and humans; nevertheless, the fact that EMF bear a negative impact has been confirmed. Plants, insects, birds, fish and mammals have been noted to have a high sensitivity to electromagnetic fields [23, 24].

Scientific literature presents scientific arguments regarding the health risks presented by magnetic fields of ultralow frequencies. Some sources state that 30% of people are sensitive to man-caused magnetic fields of 0.01-2 Hz, flux density – up to 2 mTl (changes in the activity of slow waves on an electroencephalogram). Today, more and more attention is paid to the effects associated with electromagnetic radiation below the thermal level (10 MW/cm<sup>2</sup>). New data has been obtained recently on high sensitivity of living organisms to weak magnetic fields [24-26].

In terms of environment, electromagnetic pollution should be viewed as a powerful stress factor brought into the human environment; people have not been able to adapt to this factor yet since the period of adaptation normally takes a long time, sometimes it develops over several generations. Based on the available literature, we can say that EMF have a negative impact on health and under certain conditions can serve as a background for future pathologies in people subject to chronic radiation exposure.

In humans, strong EMFs affect the immune, endocrine, and central nervous systems (CNS) that perform the alarm and regulatory functions to maintain homeostasis.

EMFs contribute to the development of ageing syndrome which takes a form of decreased capacity for work, weaker immunity, various disorders, low/high cholesterol levels, suppressed reproductive function, and age-related pathologies in early life (hypertension, cerebral atherosclerosis).

The timeline for the development of health disorders associated with EMF exposure depends on various factors: frequency range, length of exposure (length of employment), radiation localization (overall or local), EMF character (modulated, continuous, discontinuous), etc. Individual characteristics are an important factor as well. Experiments have shown that modulated EMF may cause effects that are opposite to the effects caused by non-modulated EMF. The use of a pulse-oscillation EMF in the experiment generated more pronounced biological effects as compared to con-

tinuous radiation. High biological activity of impulse radiation has been also evidenced by high sensitivity of the cholinergic system [2-4, 21, 22, 34].

In terms of health effects, the fact of contact with a magnetic field is more significant than the field's strength. Experiments show an increase in sensitivity to EMF of individual body systems caused by other environmental factors (physical fields, chemicals, pharmaceuticals, etc.). In such cases, even a short-term contact with EMF may result in a series of neurological consequences, psychological responses as well as severe pathological responses. Based on the theory of EMF non-thermal process (cyclotron resonance, conformational changes, etc.), other manifestations of negative health effects are possible.

Research on the effects of low-intensity microwave radiation (fields modulated in the frequency range of own biological rhythms of the bio-object) on the central nervous system is of current interest. It was determined that the threshold intensity for microwave radiation modulated in this range is significantly lower as compared to the ones typical of impulse and continuous radiation [10].

A low-energy microwave field modulated in the rhythms of own brain frequencies has a pronounced cardiotropic action.

When cerebral (nerve) tissue is affected by EMF with a frequency close to the frequency of own brain biorhythms, the biological effect intensifies (Table 3).

Table 3

**Harmful and hazardous frequencies (by D.S. Kontorov et al, 1993)**

<b>Rfrequency ratio, Hz</b>	<b>Negative effects</b>
0.02	Increase response time to excitation
0.06	Persistent mental inhibition.
1-3(delta-rhythm of the brain)	Stress.
5-7 (theta-rhythm of the brain)	Mental fatigue. Stress. The negative emotional arousal.
8-12 (alpha-rhythm of the brain)	It affects the reactivity and excitement until the seizure activity.
12-31(beta-rhythm of the brain)	Mental fatigue. Increased stress.
1000-12000	Reduced audioaktivnosti and auditory perception in general.
40-70	At high field strength worsening of metabolic processes. Individual physiological changes, anxiety.

About 400 (pace-making fluctuations)	Possible functional impairment.
--------------------------------------	---------------------------------

Table 4

**The clinical manifestations of human exposure to microwaves of various radiation intensities (modifications with additional data B.A. Minin [10])**

<b>Intensity of the microwaves MW/cm<sup>2</sup></b>	<b>Negative effects</b>
600	Pain during irradiation *
200	Oppression of tissue redox processes *
100	Increased blood pressure followed by a decrease in the case of chronic exposure - resistant hypotension. Bilateral cataracts.
40	Heat sensation. Vasodilation. Irradiation of 0.5-1 h increases pressure by 20-30 mm Hg *
20	Stimulation of tissue redox processes
10	Asthenia after 15 minutes of irradiation, change in the bioelectric activity of the brain.
8	Undefined blood changes resulting from a total exposure time of 150 hours, changes in blood clotting.
8	Electrocardiographic changes, changes in the receptor apparatus.
4-5	Change in blood pressure during multiple exposures, brief leukopenia, erythropenia
3-4	Vagotonic reaction accompanied by the symptoms of bradycardia and slowing of heart conductivity
2-3	Pronounced reduction in blood pressure, increased heart rate, fluctuations in the volume of blood in the heart.
1	Low blood pressure, tendency to increased heart rate, minor blood volume fluctuations in the heart. Lower IOP resulting from daily exposure for 3.5
0,4	The auditory effects under exposure to pulse electromagnetic radiation
0,3	Some changes in the nervous system resulting from chronic exposure for 5-10 years.
0,1	Electrocardiographic changes.
< 0,5	Low blood pressure resulting from chronic exposure. *

**\* intensity values are the lowest of the ones found in literature**

Below is the list of EMF-determined patterns associated with the impact of non-thermal intensity microwave fields identified by various authors:

- Affect the course of biochemical reactions of intracellular metabolism and enzymatic activity of proteins - enzymes in the brain, liver and other structures;
- Affect (directly or indirectly) the transfer of

genetic information (the processes of transcription and translation);

- Affect the levels of sulfhidralnyh and other groups determined by the polarity of protein molecules;
- Affect the neurohumoral regulation, in particular, the hypothalamic-pituitary and sympathoadrenal systems;
- Change the dynamics of the immune re-

---

sponse and physico-chemical properties of glia in particular its electron-optical density;

- Rebuild the pattern of pulse flows generated neurons;

- Change the functional activity of receptors and various ion channels, as well as structural characteristics of the clusters and water associates in biological fluids. Gender, age and state of intoxication have a significant impact on human sensitivity to weak magnetic fields [18,34].

There are two types of microwave radiation contamination in terms of dose and nature of radiation: acute and chronic (Table 4). Acute contamination includes disorders resulting from short-term exposure to microwaves with the energy density (ED) that causes a thermogenic effect. Chronic contamination is the result of prolonged exposure to microwave radiation with subthermal ED.

Specific effects of EMR are explained by the non-linear nature of the field effects on microstructures. The mechanism of microwave action lies in the changes in the cell membrane permeability which causes changes in the nucleotide cyclase system function that affects the activity of redox enzymes. The products of metabolism cause humoral changes in the physiological state.

Some authors suggest that animals and humans have specific receptors that perceive EMF. We believe that water molecules in biological fluids may act in such capacity.

Natural EMFs may be related to the processes that take place on the Sun or solely on Earth. In both cases, this phenomenon must be taken into consideration during space exploration and extraterrestrial flights [1, 11].

An interesting fact about Earth's magnetism and gravity is that both phenomena are all-permeating physical fields – nothing on Earth or beyond it can screen their impact [11].

A. Chizhevsky's argument [23] about the special inhomogeneity of helio-geophysical effects is relevant to the earthly and space environments. For this reason, it is necessary to take into account that consistent patterns that exist on Earth may not only be expressed differently when in space, but also have an opposite sign. Consequently, such situation requires adequate measures to prevent and protect from EMF [6].

Anomalous potential gradient of a magnetic field is a factor that increases the risk of cardiovascular and immune pathologies. The nature of the impact of anomalous magnetic fields on human health greatly depends on other environ-

mental factors (of toxicological and radiological nature).

Most recent scientific studies have shown that humans can interact with the resonances of Earth, noosphere, biological resonances of animals and plants, through the electromagnetic spectrum of their bodies. Through Schumann's frequency, any living being can be in resonance with the Earth. The main frequency spectrum produced by human brain lies within the range of 1 to 40 Hz; frequencies of 8-12 Hz indicate a balanced interaction with the main resonance frequency of the Earth (Table 3). The frequency coalescence here is not coincidental; it has been achieved throughout the evolution of the living beings. For this reason, any deviation is registered subconsciously, and a living object has a functional reaction to it (for example, reaction of marine animals on the approaching storm or hurricane). We can also suggest that it is alpha-rhythm (8-10 Hz) which performs the function of "by-passing", protection from weak electromagnetic effects of the external environment (Table 3).

The mechanism of impact of weak EMFs on living organisms lies within quite general physical phenomena that take place in condensed environments of various natures. The amount of water in the human body ranges from 65-80%. Water in a human body is a sixth sense used to perceive electromagnetic waves of any range and intensity. Water by definition is a structured liquid crystal environment. In a human body, water is most sensitive to low-frequency, low-intensity EMFs (< 4 Hz, by times lower as compared to the Earth's magnetic field). Here lies the danger that with the help of specially generated and targeted Schumann's frequencies one can imperceptibly influence human emotions, mood, health, and brain activity. And this is not science fiction.

In his fundamental research, V. Slesarev [19, 20] indicates that water can reagentlessly change its properties and functions as well as those of water-containing systems, by means of changing the acid-base, redox, and complexing properties. This results in changes in the spectral characteristics, solvent power, biological and physiological functions.

Water has a low-intensity electromagnetic field ( $\leq 10^{-5}$  W/cm<sup>2</sup>) which is visible in a broad range of frequencies ( $10^{14}$  Hz <  $\nu$  < 10 Hz). The electromagnetic field of water is registered in the conditions of growing ice, and in liquid condition – at various ranges from mm to km.

Real biochemical and biophysical reactions in biological structures occur with discrete potentials: -0.40; -0.10; 0.19; 0.49 и 0.78 W at pH =7.5 (extreme values - potential degradation of water, cessation of vital processes).

In water, a qualitative difference between magnetic density and magnetic intensity disappears. Alternating low frequency (0.01-0.04 Hz; 1-7 Hz, etc.) and low-intensity (5-50  $\mu\text{W}/\text{cm}^2$ ) magnetic field affecting water experimentally causes a number of changes in its physical parameters which maintain for 72 hours.

Based on the spatial, geometrical, and qualitative characteristics of water associates, they can be viewed as an active participant and catalyst of various biochemical processes [9]. It is water associates which can lower the energy barriers for the chemical, biochemical and biophysical reactions to take place.

Any electromagnetic energy and available frequency information are addressed to specific water, neuronal, protein and associated structures of a living organism – twins of this information.

In the last 10-15 years, the intensity of all Schumann's resonances (waves) has been growing, so humans naturally perceive EMF in the range of 4-7 Hz and 13-40 Hz. Schumann's lower frequency, 7.83 Hz, is changing and approaching 8 Hz and sometimes higher. The second and third Schumann's resonances are also fluctuating between 0.3 and 0.8 Hz respectively.

Due to lack of studies about the mechanism of the biological effects of weak EMFs of any nature on living organisms, there are debatable statements and episodes of rush around avian influenza, aspecific pneumonia, unexplainable emergence of new virus-like diseases and emerging activity of neutral biological structures. We believe that progressing industry-related magnetic background, changes in the frequency responses of Schumann's resonances, closed test-runs of various devices that generate low frequency electromagnetic waves can be the cause of sudden epidemics.

Based on today's ideas and scientific discoveries, we can outline some features to prove the above statement.

**Oscillating processes in biological structures** are significantly affected by EMFs. A response to external impact is a structural change in the body of humans and animals of individual water molecules as well as bound water, clusters and water associates which structurally repeat the shapes of submolecular, molecular and cellular structures

including cell membranes. Water structures of an organism are the main source of infra-red radiation and also a regulator of its biochemical and biophysical processes.

When a biological object is exposed to radiation, electromagnetic energy is absorbed mainly by water molecules, as a result, the following is observed [5, 9]:

- An increase in the kinetic energy of the molecules, molecular groups, selective heating of microstructures (dielectric loss) with occurrence of unusual temperature gradient;

- Orientation of the molecules and larger particles along the lines of EMF, relaxation and polarization of the molecules;

- Induction charges in the particles;

- Rotation of dipole molecules, resonance vibrations of molecules, ions, protein chains;

- Increased permeability of cell membranes, ionic change in diameter (membrane channels), disruption of ionic currents ( $\text{Ca}^{+2}$ ,  $\text{K}^{+}$ , etc.), A change in cell membrane potential)

- Changes in the dielectric properties of the tissues – in low frequency ranges - induced electrical charges on the subcellular and larger structures and the distribution of the induced charge on the surface of the body (the change in density induced current).

Oscillating processes in biostructures trigger anomalous gradients of ion concentrations, changes in the areas of protein hydration, disruptions in the loosest bonds of large protein chains, changes in the molecular structures responsible for the non-specificity of proteins and enzymes, conformational changes in the membrane protein, changes in the exchange rhythms in the water phase and, eventually, non-thermal protein denaturation, tissue function abnormality, increased concentrations in metabolism products, cell damage, local arousal of receptor formations and development of reflex biological responses in an organism.

In general, a pathophysiological process begins on a molecular level. From there, the reaction (on the organismic level) follows a stereotypical pathophysiological pattern: stimulation, inhibition, sensibilization, deadaptation, accumulation, depletion. The pattern of organismic responses to the EMI effect is similar to those of other stimuli in terms of phase-based processes, nonlinearity of responses, reversible changes, accumulation of biological effects dependent on the intensity and duration of exposure, the initial state of the body.



The change in the most sensitive structures of the nervous system is an early response to low-intensity EMR. Morphological changes resulting from short-term irradiation are reversible; as for long-term irradiation, the changes are an expression of protective-adaptive processes (degenerative changes in parenchymal organs and the seminiferous tubules, proliferative response reticuloendothelial elements of the liver and brain microglia). The most drastic changes are registered in interneuronic bonds of the cortex axosomatic synapse and sensitive fibrils of the paratopic areas of the skin and internal organs.

Low-intensity EMR triggers fugitive functional changes. Here, the systems which are more sensitive to EMR (central nervous system, endocrine system) are the first to respond to the impact; less sensitive systems have a delayed response. Individual sensitivity is also important; it determines the response rate which in its turn distinguishes a physiological response from a pathological one. EMR can have an "informative" effect, especially in the conditions of a significant health disorder (diseases, overwork, and harmful interference of other factors). The effect of the radiation shows, first of all, in the low-term processes (advanced extremely high frequency therapy is based on this).

Under EMR, the biological effects (synergistics) of the structured molecules of biological fluids have particular properties. There is a large amount of harmless bacteria and virus-like protein molecules in an organism. Due to the above effects, they transition from a harmless state into the state of pathogenic etiological agents. A modified structured background of the biological fluids plays an important role here, too. Our preliminary studies show that as little as 1 ml of the physiological solution structured by a low-frequency generator and administered abdominally (0.5 ml) to mice or intravenously to humans can both activate physiological processes in an organism and have a static or lytic impact on hepatitis C virus.

Yet a single rearrangement of the hydrogen molecule or changes in the structural order of the of the active site molecule can impact the pathogenic power of bacteria, viruses, and harmless protein molecules due to the changes in the protein space structure.

From physics we know that substance can

turn into energy and back. It was N.I. Pirogov who wrote about the unity of "power and substance" in the "Diary of an Old Doctor" [SPb.; Addendum to the digest "Russkaya Starina", 1884. – 464 p.]. From looking at more recent studies about the microcosm and electrodynamics, it becomes clear various microelectric fields in a body (electric fields with a "micro" prefix, but at the micro-level their value is sufficient) create a transition of singular fundamental particles (either electrons or other light fundamental particles) into energy; these small energy portions are enough for the functioning of various human organs.

Speaking of heart, academician E.I. Chasov said that this organ is virtually an electric motor itself; there are enough points on the heart's surface with different electric potential, and different parts of a heart have electrical currents. By having said this, E.I. Chasov implicitly raised a number of questions to the scientists. It seems that individual fundamental particles also transition into energy inside the heart and thus feed this important organ in accordance with the general law of the energy appropriateness of diet.

At the molecular level (of a living organism), only very small affecting impulses are needed (several photons are enough) which have a significant impact on thin biological structures, whose angular variations have significant functional consequences. This data corresponds with the term "structural stability" suggested by I.R. Prigozhin in his book "From Existing to Emerging" [27]; here this term is discussed in the context of development of certain situations after the impact of fluctuations on the system – the so-called "order through fluctuation". The main approaches to this topic are outlined in the book by I. Prigozhin co-authored by G. Nicolas "Self-Organization in Nonequilibrium Systems: From Dissipative Structures to Order Through Fluctuations" [28]. The models "order through fluctuations" are unveiling a nonequilibrium world where small causes lead to major consequences. The reason for the magnification of small events is quite a legitimate subject of rational analysis. Same non-linearities can make order out of the chaos of fundamental processes, and under other circumstance bring about the results of the same order and, eventually, a new coherence (oscillating or wave processes, coordinated in time, with

a constant phase differential) laying beyond a different bifurcation. The achievements of biological synergetics of non-linear non-equilibrium dynamic open systems clearly explain the mechanism behind the effect of weak and superweak physical fields on biological structures of an organism [29-32]. Every biological and biochemical structure in a living organism has its own spatial position of a molecule. Structural changes in water molecules in an organism can change the angular orientation and the direction of rotation of one biological molecule atom against the other, one molecular group against the other. The chemical composition in this case is constant, chirality does not change – the spatial structure changes and, respectively, biological effects emerge. For example, xenon clusters or post-xenon water associates in biological fluids. Chromosome chain breakages take place under non-thermal radiation of different nature – it is the level of interaction between a biological structure and a biological fluid [5-6, 24-25,33]. The spatial position of the biological molecules of all shapes and other biological structures in an organism is maintained by the internal electrostatic and weak electromagnetic interactions typical of every living organism individually as well as by control electromagnetic radiation from the environment (of cosmic, circumtellurian, terrestrial and industrial nature). Terrestrial force fields, Schumann resonances, saturation with electromagnetic smog of technogenic origin, and geopathogenic zones have a low intensity, but extended time of exposure. Affecting the main CNS rhythms, they can break the cerebral control impulses and thus change the immunological status of the organism in general as well as the spatial structures of the immune molecules shapes.

Living structures, as in all the nature, are organized in fractals (a fractal is a fairly simple structure that consists of parts which are similar to the whole; it has become a single element of the Mandelbrot family fractals [Benoit B. Mandelbrot. *The Fractal Geometry of Nature*, 1977]). A change in the components of any fractal at the micro-level in organized systems even under low and super-low exposure (lower than kT- mean energy of the thermal motion of one molecule that equals 0.03 eV) is reflected at the macroscopic level in the change of the shape and function of the whole. There are plenty of examples in nature. Water structures in any living organism are the basis of the phase con-

nection of fractal resonators; they also maintain the coherence of the biological system at each of the hierarchical levels. Only because of biological fluids, all the thin structures respond to external exposure, including EMR, in the same way. Small-scale interaction in the system can have both positive and negative effects.

Serving as the fundamental receptor of all the electromagnetic effects, in our opinion, structural formations of biological fluids are the first link on low and super-low effects both inside an organism and in sensitivity to (perception of) external irradiation. Water in a living organism defines the biological compatibility of molecular components and metabolic variability. The functions of liver, kidney and other systems depend on the condition of the biological fluids, redox and metabolic processes (living – dead water [9]).

The change in the internal control impulses of a biological system at all the hierarchical levels (ranging from local to regional and central) under external exposure, including weak exposure, can result in stress, depression, non-specific decrease in the immune response, and, consequently, predisposition to various infectious, virus and other diseases.

Our studies show that the impact of structured low-frequency or weak low-frequency low-intensity radiation on physiological solution leads to increased treatment effect from the preparation that was preliminary affected by EMR [5, 33].

We can suggest the ways to correct the impact of geomagnetic field (GMF) on human or animal organism. If a low level of GMF activity is undesirable, partial shielding of an the organism must serve as the factor that compensate for the influence of the Earth's magnetic field. And, vice versa, if a high level of GMF activity is undesirable, then it can be compensated by applying an EMF whose frequency is close to cyclotron. Naturally, these arguments require further testing.

When a human (animal) finds themselves in a new environment (microclimate) with low-intensity low-frequency electromagnetic fields, their bodies experience new internal responses and re-arrangements. In this regard, not only human habitat on Earth should be paid attention to, but also extended space travel and exploration [1, 11]. The frequency rhythms that people on Earth are used to are based on Earth's main resonating fre-

quency, but on other planets it is different. For this reason, fundamental studies on human safety in space are very important and actual.

In conclusion we would like to point out that with the account for the ubiquity of artificial EMF sources both in the workplace environment and at home, lack of sufficient information about

the nature of their negative biological impact, the World Health Organization (WHO) considers electromagnetic pollution to be one of the major issues that the humanity is currently facing and implements a large-scale program called "The International EMF Project"; Russia is one of the program's participants.

## References

1. Dovgusha V.V., Tihonov M.N., Kudrin I.D. et al. Biologicheskoe dejstvie nizkointensivnyh jekologicheskikh faktorov na organizm cheloveka [The biological effect of low-intensity of environmental factors on the human body]. *Jekologija prom. proizvodstva*. – 1999. – № 1. – P. 3–14.
2. Nikitina V.N., Lashko G.G., Kopytenko Ju.A. et al. Gigienicheskaja ocenka magnitnyh polej v jelektropoezdah i tehnologicheskikh zonah metropolitena [Hygienic evaluation of the magnetic fields in electrical and technological areas of the subway]. *Med. truda i prom. jekologija*. – 2002. – № 3. – P. 16–18.
3. Nikitina V.N., Fominich Ye.N., Myrova L.O. i dr. Gigienicheskie issledovanija jelektromagnitnoj obstanovki v jekranirovannyh sooruzhenijah [Hygienic researches of the electromagnetic environment in the screened constructions]. *Morskoy med. zhurnal*. – 1999. – № 5. – P. 17.
4. Dovgusha V.V., Dovgusha L.V. Jelektromagnitnye polja: Rol' i mehanizmy kontrolja nad soznaniem i zaboлеваemost'ju [Electromagnetic fields: the role and mechanisms of mind control and morbidity]. *Medicina jekstremal'nyh situacij*. – № 2(24). – P. 49–59.
5. Dovgusha V.V., Lehtlaan-Tynisson N.P., Dovgusha L.V. Voda privychnaja i paradoksal'naja [Water familiar and paradoxical]. – SPb., 2007. – 242 p.
6. Dovgusha V.V., Tikhonov M.N. Jelektromagnitnyj faktor – istochnik mnozhestva zabolevanij [Electromagnetic factor - the source of many diseases]. *Medicina jekstremal'nyh situacij*. – 1999. – № 1. – P. 5–10.
7. Dovgusha V.V., Tihonov M.N., Dovgusha L.V. Volnovye vzaimodejstvija v biologii i medicine [Wave interactions in biology and medicine]. – SPb.: Poligraf-Atel'e, 2012. – 286 p.
8. Kopytenko Yu.A., Ptitsyna N.G. et al. Zagrizaznenie gorodskoj sredy ul'tranizkochastotnymi magnitnymi poljami ot jelektrotransporta // Pogoda i biosistemy [Urban pollution by the extra-low-frequency magnetic fields from electric transport]. *Mater. IV Mezhd. kongressa*. – SPb., 11–14 October, 2006. – P. 85.
9. Zenchenko T.A. Analiz harakternyh osobennostej geofizicheskoy obstanovki v momenty aviacionnyh proisshestvij, proizoshedshih po raznym faktoram-prichinam [Analysis of the characteristics of geophysical conditions in date of the accident that occurred on various factors, reasons]. *Slabye i sverhslabye polja i izluchenija v biologii i medicine: Mater. IV Mezhd. kongressa*. – SPb., 11–14 October, 2006. – P. 142.
10. Kalninsh K.K. Kataliticheskie svojstva vody: «zhivaja» i «mjortvaja» voda [The catalytic properties of water: "live" and "dead" water]. V kn.: *Bioinformacionnyj resurs cheloveka: rezervy obrazovaniya. Mater. nauch.- obrazovat. konf.* – SPb., 2004. – P. 128–185.
11. Kontorov D.S., M.D. Kontorov, V.K. Spoka. Radioinformatika [Radio informatics]. – M., 1993. – 204 p.
12. Avakyan S.V., Voronin N.A., Borovkova O.K., V.V. Kovaljonok. Mezhplanetnye pilotiruemye poljoty v otsutstvii geomagnitnyh pul'sacij – psihofizicheskij aspekt [Interplanetary manned flights in the absence of geomagnetic pulsations - psychophysical aspect]. *Slabye i sverhslabye polja i izluchenija v biologii i medicine: Mater. IV Mezhd. kongressa*. – SPb., 11–14 October, 2006. – P. 157.
13. Minin B.A. SVCh i bezopasnost' cheloveka [Super-high frequency and human safety]. – M.: Sovetskoe radio, 1974. – 348 P.
14. Nikolis G., Prigozhin I. Poznanie slozhnogo [Complex cognition]. – M.: URSS, 2003. 15. O sostojanii okruzhajushhej sredy v Sankt-Peterburge i Leningradskoj oblasti v 1998 godu: Gosudarstven-

---

nyj doklad v 2 t. [On the state of the environment in St. Petersburg and Leningrad region in 1998: State Report 2 tons.]. – SPb., 1999. – Vol. 1. – 193 p.

16. Prigozhin I. Ot sushhestvujushhego k voznikajushhemu: vremja i slozhnost' v fizicheskikh naukah [From Being to Becoming: Time and Complexity in the Physical Sciences]. – M.: URSS, 2002.

17. Prigozhin I.R. Postizhenie real'nosti [Reality comprehension]. Priroda. – 1998. – № 6. 18. Prigozhin I., Stengers I. Porjadok iz haosa [Order out of chaos]. – M.: URSS, 2003.

19. Reshenie Soveta bezopasnosti RF ot 20.02.1995 g. № 2-2 «Ob opasnosti jelektromagnitnogo zagrjaznenija okruzhajushhej sredy» [The decision of the Security Council of the Russian Federation of 20.02.1995, № 2-2 «The danger of the electromagnetic environment pollution"].

20. Rudakov M.L. Rossiyskie i evropejskie gigenicheskie normativy na parametry radioizluchenij dlja naselenija [Russian and European hygienic standards on the radio parameters for the population]. Standarty i kachestvo. – 1996. – № 4.

21. Ryabov Ju.G., Osipova A.Yu. Normirovanie jelektromagnitnoj bezopasnosti bytovyh priborov v Rossii i SShA [Rationing of electromagnetic safety of household appliances in Russia and the US]. Standarty i kachestvo. – 1996. – № 5.

22. Sanitarnye pravila i normy «Jelektromagnitnye izluchenija radiochastotnogo diapazona» (SanPiN 2.2.4/2.1.8.055-96) [Sanitary regulations and standards "Electromagnetic emissions of the radio-frequency range" (SanPiN 2.2.4 / 2.1.8.055-96)].

23. Serpov V.Ju. Bezopasnost' zhiznedejatel'nosti cheloveka v zonah geofizicheskikh anomalij Evropejskoj Rossii [Vital activity security in the areas of geophysical anomalies in the European Russia]. – SPb., 2005. – 128 p.

24. Slesarev V.I. Zagadki vody. Strukturno-informacionnoe svojstvo vody i javlenie «akvakomunikacii» [Mysteries of water. The structural and information property of water and the phenomenon of "aqua communications"]. Voda i jekologija (Problemy i reshenija). – 2004. – № 4 (21). – p. 49–83.

25. Slesarev V.I. Osnovy himii zhivogo [Principles of chemistry of vivo]. – SPb.: Himizdat, 2007. – 787 p.

26. Tikhonov M.N. Jelektromagnitnaja bezopasnost': vzgljad v budushhee. Problemy kompleksnoj zashhity organizma pol'zovatelej pri jekspluatácii komp'juternoj tehniki [Electromagnetic safety: looking into the future. Problems of complex organism protection of users in the operation of computer equipment]. – M.: VINITI RAN, 2005. – № 3. – p. 9–47.

27. Tikhonov M.N., Dovgusha V.V. Jelektromagnitnaja bezopasnost': postizhenie real'nosti [Electromagnetic safety: reality comprehension]. Jekologicheskie sistemy i pribory. – 1999. – № 4. – p. 43–55.

28. Tikhonov M.N., Dovgusha V.V., Kudrin I.D. Obshhestvo v uslovijah tehnogenogo pressinga jelektromagnitnyh izluchenij [Society in terms of technogenic electromagnetic radiation pressure]. Jekologija prom. proizvodstva. – 1998. – № 3–4. – p. 11–32.

29. Tikhonov M.N., Kudrin I.D. Chelovek i tehnika; «obshhenie» poljami [Human and Technology; "Communication" by fields]. Jenergija: jekonomika, tehnika, jekologija. – 1997. – № 11. – P. 26–27.

30. Hagen G. Sinergetika: ierarhii neustojchivostej v samoorganizujushhihsja sistemah i ustrojstvah: Per. s angl. [Synergetics: Instability Hierarchies in self-organizing systems and devices: Trans. from English.]. – M.: Mir, 1985. – 320 p.

31. Chizhevskij A.L. Kosmicheskij pul's zhizni [Cosmic Pulse of Life]. – M.: Mysl', 1995. – 768 s.

32. Crasson M. et al. Absence of daytime 50 Hz, 100  $\mu$ Trms magnetic field or bright light exposure effect on human perform. P... ance and psychophysiological parameters // Bioelectromagnetics. – 2005. – Vol. 26, № 3. – P. 222–233.

33. Fuller M., Dobson J. On the significance of the constant of magnetic field sensitivity in animals // Bioelectromagnetics. – 2005. – Vol. 26, № 3. – P. 234–237.

34. Gordon C., Berk M. The effect of geomagnetic storms on suicide // Safr Psychiatry Rev. – 2003. – Vol. 6. – P. 24–27.

35. Prigogine I., Nicolis G. Self - Orgazation in Non-Equilibrium System: From Dissipative Structures to Order Through Fluctuations. – New York: J. Wiley&Sons, 1977.