

M.S. Markov**ELECTROMAGNETIC FIELDS IN BIOSPHERE: BENEFIT AND HAZARD**

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Abstract

This paper is written in order to summarize the role of electromagnetic fields in the origin and evolution of life on Earth, as well as hazard and benefit from electromagnetic fields. It is an attempt to show that today the mankind and the entire biosphere are subjected to a global experiment conducted without protocol, monitoring and even knowing the parameters of the applied electromagnetic fields. At the same time, electromagnetic fields used in magnetotherapy has been proven to be beneficial in treatment of various health problems. Magnetotherapy is non-invasive, safe, and easily applied methods to directly treat the site of injury, the source of pain, and inflammation. The development of advanced communication technologies year after year increases the hazard for the biosphere and mankind. The paper discusses the contradiction between scientists and technological engineers in the line thermal or nonthermal are effects of electromagnetic fields. The specific problems with children health are analyzed. It focused on the facts that at the end of the second decade of this century more aggressive mobile communications, such as 4G and especially 5G are being introduced in the North America and Europe without any attempt to evaluate the hazard for civilization.

Key words: *electromagnetic fields, mobile communication, public health, protect children*

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History

The contemporary science recognizes that natural electromagnetic and especially magnetic fields have been factors that accompanied the development and evolution of the planet Earth and life on the planet. In historic sense, people understood early that some natural material might help in some cases of injuries and diseases. A legend suggests that a Greek shepherd in the hills near the village of Magnesia (which exists today in Turkey under the same name) found stones that attracted his sandals, and soon these stones were used to treat certain maladies.

The problems of hazard of electromagnetic fields arises in the last two decades of the XX century and quickly became of serious public interest. However, the role of natural and man-made magnetic and electromagnetic fields on human life are still not well understood and investigated.

Ancient physicians in China, Japan, and Europe applied natural magnetic materials for the treatment of various diseases. One of the earliest scientific accounts is in the book *De Magnete*, written in 1600 by William Gilbert, the personal physician of the English Queen [1].

After World War II, magnetotherapy developed quickly in Japan and later in Romania and the former Soviet Union. Magnetotherapy has a long history in Europe. During the period 1960–1985, most European countries had produced magnetotherapeutic systems. The first clinical application of electromagnetic stimulation in the USA appears to be 1974 [2]. The first book on magnetotherapy, written by Nentcho Todorov, was published in Bulgaria in 1982 and reviewed the use of electromagnetic fields for treatment of more than 2,700 patients with 33 different pathologies [3]. It would be fair to say that the second half of the XX century marks significant increase of the clinical application of electromagnetic fields (EMF). In parallel, world biophysics, biomedical engineering and clinical science performed both basic research and clinical assessments of the results of EMF applications for therapy.

During this period serious contribution of the soviet science (and further the science of former soviet republics) should be reminded. Nearly every year at least two all-

union conferences had been organized. Some of them attracted scientists from European countries. With active participation of Prof. Yuri Kholodov were organized and some international projects. For nearly 10 years (before the collapse of the USSR) a National Commission on Magnetobiology and Magnetotherapy was functioning in order to stimulate developments in these two areas. In 1989 during the first Soviet-Bulgarian Symposium held in Bulgaria was created Association of Magnetology.

At the yearly meetings of BEMS (BioElectroMagnetic Society) and by-annual meetings of EBEA (European BioElectromagnetic Association) for decades the problems of magnetobiology and magnetotherapy have been discussed. Started by Greek biophysicist Panos Kostarakis in 2000, every two years Mediterranean meetings on biological effects of electromagnetic fields took place nine times. Probably, it should also be mentioned two International School on “EMF and biomembranes” that took place in Bulgaria in 1986 and 1989.

Magnetic fields (MF) have been proven to be clinically safe, and it is well accepted that MF provide a practical, non-invasive method for inducing cell and tissue modifications which can correct selected pathological states.

In the last decade, the research has been principally concentrated to the hazards of cellular phone communications. Both power line and cell phone issues have attracted the attention of the news media, industry, and policy makers and, as a result, there have been significant funding for research in these areas.

The public fear as well as scientific community pursued the World Health Organization (WHO) to recognized the importance of this problem and to start “The international EMF project” which main goal was to harmonize standards for EMF radiation and exposure. During the last two decades WHO organized a series of international meetings in different locations of the world with intention to harmonized standards. Unfortunately, this activity did not end with a more or less defined conclusion, or at least recommendation. In respect of EMF used in mobile communications, the International Agency of Research on

Cancer (IARC) has recognized the microwaves as possible carcinogenic source (category 2B).

However, the role of natural and man-made magnetic and electromagnetic fields in the origin and evolution of life as well as the effects of contemporary magnetic/electromagnetic fields on human life are still not well investigated and understood. Both, hazard and benefit of these fields are subjects of various studies and review papers and very often the conclusion is “this is a controversial issue”. Behind this statement one can see the superficial approach to the problem which is mainly due to the fact that the problem is not well defined. The hazard from exposure to magnetic/electromagnetic fields is due to continuous exposure to these physical factors. They act in long periods of time, in combination with other physical and chemical factors. Contrary, the proven benefits of clinical use are result of short sessions of exposure to known magnetic/electromagnetic fields in controlled conditions. The therapeutic fields in most cases are orders of magnitude stronger than natural fields, but they are applied for short periods of time (usually 30–45 min a day) and in controlled conditions.

The brilliant Soviet magnetobiologist Yuri Kholodov four decades ago wrote a book “Man in the Magnetic Web” [4]. Long before occurrence of mobile communications, Kholodov pointed out that the entire biosphere is immersed in the ocean of the electromagnetic waves. Note, at that time there was no Internet, nor mobile communications. But the mankind slowly became immersed in the millions and millions electromagnetic fields from satellite, radio and TV emitters.

The scientific and medical communities developed clinical modalities that have been proven as effective approach in clinical medicine. Number of books had been published which basically reported the benefit of this approach, starting in 1986 with the Handbook of Biological Effects of Electromagnetic Fields [5], written by Polk and Postow which had three editions, latest edited by Barnes and Greenebaum in 2007 [6]. In 2004 Rosch and Markov published “Bioelectromagnetic Medicine” [7]. In 2015 Paul Rosch edited “Bioelectromagnetic and Subtle Energy Medicine” [8], and Markov edited “Electromagnetic Biology and Medicine” [9].

Mechanisms of Detection and Response to EMF

The fundamental question for engineers, scientists, and clinicians is to identify the biochemical and biophysical conditions under which applied electromagnetic fields could be recognized by cells in order to modulate cell and tissue functioning. It is also important for the scientific and medical communities to comprehend that different magnetic fields applied to different tissues could cause different effects. Hundreds and hundreds of studies had been performed in search of one unique mechanism of action of magnetic field on living systems. It would be fair to say that these efforts have been determined to fail. It is impossible to get the same response to specific EMF at bone and soft tissue, at elephant and butterfly, and at microorganism and buffalo. Biology also knows that the

geographical and climate conditions created genetic and physiological differences in the organisms from the same species and therefore their response could be different.

The problem of mechanisms of interactions might be discussed from different points of view, engineering and physics, biology, and medicine. The signal-transduction cascade allows the biological response to the applied EMF on simple structures such as cellular membrane or specific proteins, conformational changes, and/or charge redistribution and by signal-transduction mechanism can be spread over the cell or tissue. In a recent paper Belyaev (2014) emphasizes that the biological systems are not only non-linear, but also non-equilibrium systems [10].

Evidently, there is a large body of basic science and clinical evidence that time-varying electromagnetic fields can modulate molecular, cellular, and tissue function in a physiologically and clinically significant manner, most recently summarized in several books and review articles [6, 7, 11–14].

Contemporary EMF conditions and hazard with Wi-Fi communications

Hazard from EMF

Frequently news media discuss the danger of electromagnetic fields for human and environmental health, especially in relation to cancer initiation. The hazard issue in the western scientific community has been discussed beginning with the power-line electromagnetic fields and continuing with wireless communications.

The fast development of satellite communications, followed by wireless communications and Wi-Fi technology, dramatically changes the electromagnetic environment. To continuous action of complex and unknown (by sources, amplitudes, frequencies) electromagnetic fields is exposed entire biosphere and every organism living on this planet [9].

The evaluation and prediction of the potential adverse effects from wireless communications (any mobile device, including), especially by children, becomes a question of crucial importance. The twenty-first century is marked with exponentially increasing development of technologies for wireless communications.

It is not well known that a simple cellular telephone delivers a power density of radiofrequency radiation which is about 2 billion times greater than similar fields that occurs naturally in the environment. Since the mobile phones are designed to operate at the side of the user's head, a large part of the transmitted energy is radiated directly into that person's brain. Therefore, the absorbed energy potentially could cause dangerous and damaging biological effects within the brain.

The hazard from high frequency electromagnetic fields used in the XXI century communication is frequently labeled as “controversial”, and it is absolutely incorrect. It is not controversial issue, it is conflict of interest of industry on one side and mankind and environment on the other.

In the summer of 2011 the IARC classified radiofrequency EMF as possible cancerogene [15].

Immediately after the publication of this qualification, IARC was target for complains from industry and engineering committees like ICNIRP (International Commission on Non-Ionizing Radiation Protection) and IEEE (Institute of Electrical and Electronic Engineering). Speaking on the potential hazard of Wi-Fi technologies, one should not forget that it includes not only mobile phones but also more importantly all means of emitters and distributors of Wi-Fi signals, mainly antennas, base stations and satellites.

In many public locations, specific systems of distribution Wi-Fi signals are introduced in order to facilitate the work performance. Well, this might be understood. However, I do not understand why Wi-Fi communications are secured in the subway tunnels and aircrafts? It obviously requires high and oriented power to which are exposed all passengers in the trains and planes just to make comfortable the users of mobile devices. It is forgotten that in confined subway tunnels and planes significant power of the signal is needed.

It is my belief that a special attention should be paid to the potential harm that the XXI century society cause on children. They are realities of our life and it is now impossible to protect children from the “cocktails” of electromagnetic radiation XXI century offers. It became unfortunate reality that children are the most aggressive part of users of wireless devices – starting from toys to tablets, to smart phones [16]. And even worst, their bodies and brains became exposed to RF EMF radiation nearly from their birth and in most cases, they start using computerized toys as early as in the age of one year. The exposure of newborn children to RF EMF will be longer and stronger than the exposure of their parents.

The cell phone users are seriously misled. When buying a cell phone they assume that this radiation emitting device was tested for safety in human health. This is wrong: the cell phones have never been tested in respect of their impact on human health. For the first time in human history radiation-emitting devices were placed directly to human head and exposed human brain to microwave radiation. The industry is rushing to develop, manufacture and sale their new devices. The business always said “the market will gudge our product” and the health issue is not their priority. Unfortunately, regulatory agencies are consisting of engineers, lawyers, business people. The health experts are missing.

The industry executives, engineers and dosimetry experts continuously misrepresent the issues related to potential hazard of cell phone radiation. The engineering committees of ICNIRP and IEEE continue to mislead scientific and medical communities, as well as the general public that the only meaningful effects of EMF are thermal.

In 1995 the former industry executive Robert Kane publish a very interesting book “Cellular telephone: Russian roulette”, which unfortunately is not well known: “Never in human history has ever been such a practice as we now encounter with the marketing and distributing of products to the human biological system by an industry with foreknowledge of those effects” [17].

Let me remind that human head is a complex structure of many different tissue types. Each of these types – skin,

bone, fat, cerebrospinal fluid, brain, dura absorb RF energy in its own way. In addition, even having the same structural components, different heads varies in volume and shape. It is evident that there is a significant difference in the size of adult and baby head. Besides the size difference, more important is the fact that the children’s brain is in process of development and any exposure to RF is more detrimental for children than for adults.

To make the story more complicated, I should point that for obvious reasons the biological effects of ionizing radiation are continuously studied from 1945 till now. It is completely different with non-ionizing radiation. What do we actually know about nonionizing radiation? Basically NOTHING. Even the simplest and longer studied behavior of natural magnetic, electric and electromagnetic fields is far of complete knowledge.

Non-ionizing EMF are frequently discussed under the umbrella “radiation” and for this reason, the research of effects of electromagnetic field is going in parallel with studying the effects of ionizing radiation. As basic physics teaches, radiation involves energy, and for that reason the energy interactions with any physical or biological body are connected with damage or heating of the body when the intensity of the radiation is above certain threshold level. Yes, this is correct for ionizing radiation because the effects of ionizing radiation are energy based. For decades the same approach has been applied in non-ionizing research. There is one very important aspect which this approach is missing. In ionizing radiation the damage of the exposed tissue is “global” – all cells are damaged nearly simultaneously without chain of biochemical pathways. In the case of non-ionizing radiation, certain cells or even cell components might be affected first, and then signal transduction pathway might cause changes in the protein conformation and speed of biochemical reactions, for example.

The idea of thermal effects in bioelectromagnetics had been introduced and became the subject of intensive discussions, related to specific absorption rate (SAR) as useful criteria. Yes, it is obvious that the SAR is a useful criterion, and the only criterion, which could estimate the energy absorbed by the body. However, the name clearly indicates absorption and I wonder why for so many decades the SAR was used to identify the energy delivered by the generating system. Up today, SAR is more often used to describe the energy delivered by the source of EMF. One can only wonder how a device may be characterized by SAR. Let me repeat, the SAR identifies the amount of energy that is absorbed in a gram of tissue. The use of the SAR, should be a measure of absorbed energy, and for that reason serious modifications of guidelines and standards in terms of internal energy absorption in addition to power density at the surface must be done.

Because of activity of engineering community a lot of efforts and funds have been spent to prove the thermal effects of EMF, while nonthermal effects they tend to neglect. We should point that biological systems are non-linear systems and plenty of biophysical studies demonstrated that non-thermal effects prevail in laboratory and clinical settings

[12]. The non-thermal character of interactions between EMF and living systems have been discussed elsewhere [10, 18, 19].

Let me distinguish two types of dosimetry that obviously need to be used in evaluation EMF impact on human body: physical and biophysical dosimetry. The physical dosimetry could describe the parameters of the generating system of the specific device. In most cases these parameters are calculated by basic engineering principles and most often without real measurements. The biophysical dosimetry is always based on measurements. It is important for biology and medicine to have knowledge for the exact magnetic field at the target site. In most cases, the target is located at certain distance from the applicator. One significant advantage here is the fact that for static and low frequency magnetic fields (as most of the therapeutic devices are) the magnetic and dielectric properties of the biological tissues are similar to the properties of air. This allows biophysical dosimetry to be performed in air and basically to create 3-D structure of any signal in use in laboratory or clinical settings. But the situation is quite different with RF EMF and especially with millimeter waves in new 4G and 5G technology.

Mobile communications basics

Recent data shows that at present the number of mobile devices surpasses 7.5 billion users not counting increasing distribution of smart phones and electronically driven utility meters. It is obvious that the tighter integration between the mobile devices and smart home environments will ultimately provide the infrastructure with a wide range of applications, further personalizing consumer and citizen interaction with the world around them. It is even not fair to say “emerging mobile phone technology of 4G and 5G modalities” – it is already reality in today world. For me, these two new technologies open large window for potential hazard for biosphere and mankind.

I need to point out that after more than a quarter of century of use we do not understand to which extent the EMF from mobile communications represent hazard for public health. What is worst, we do not have identification of the conditions and parameters of RF EMF at which the exposure of the population to these microwaves became chronic. The population is exposed to this radiation with no knowledge for the exposure, nor for the parameters of received EMF. I believe that it is correct to say that the international system for control and regulation had failed. In order to get license, the manufacturers need to fulfill some technical guidelines which are far away from the requirements of regulators for medical devices, which are applied for a short period of time. Even if some research on health consequences is done, it happened far after the technology is in use for years. In most cases such studies are focused to prove that at these parameters thermal effects cannot occur. If so, regulator said, there is no problem for users, nor for the population. One may read publication for the effects of new mobile technology which in best case scenario include control group (which do not use this specific device). The question is – if this a real control.

What the investigator knows about the radiation volunteer received prior to the study or even during the study from surrounding source of EMF?

Let me point that for 30 years of development of mobile technology situation changes dramatically. Today smartphones are portable, powerful computers which are “on” immediately after the battery is installed. The unit is “on” 24/7 receiving and emitting information, data, etc. While wireless technology has developed from generation to generation, today, the situation is different – the problem is not to upgrade – any new generation is basically new technology. It is even more true especially for 5G which is a step deep in the millimeter range of electromagnetic spectrum. For this new frequency range, the proper distribution of the signal requires a large number of antenna elements. At the moment I am writing even the technical standards for 5G are not yet available. As result, the society is jumping in new technology which will place the entire biosphere and civilization to new levels of electromagnetic pollution which are not defined, for which has no standard and methods of control.

Like entire development of wireless communication the industry is pushing to first develop mobile devices and networks and further developed the standards [20]. We had been on this avenue for about a quarter of century. Didn't we learn something? Consequently, “smart operators and providers are learning all they can about 5G now to understand how they will need to evolve their backhaul strategy to create more effective and financially viable business models”.

The industry is pushing for development of controversial legislation to expedite the distribution of this new technology. The local governments and private citizens will face situation when they cannot oppose the dense installations of antennas (at every 20 houses in urban area). Since the distribution of millimeter waves is blocked by buildings and even walls, it may happened that at any school or office building several transmitter will need to be placed in each floor of the building.

The FCC (Federal Communication Commission in USA) in 1996 introduced a limit for thermal effects from EMF of 1.5 to 100 GHz to be 1 mW/cm² for 30 min use. This limit was set 20 years ago and is related only to thermal effects. The engineering community up today continue claiming that nonthermal effects of EMF do not exist. This statement is absolutely incorrect and negate hundreds of publications reporting nonthermal effects of EMF. I would emphasize here that most of reports of effects of millimeter waves have reported short term exposure while practically there is no information about long term exposure. Even the short exposure to millimeter waves was reported to cause significant non-thermal effects [21].

Thermal vs. nonthermal effects

It is a very important in electromagnetic biology, medicine and public health to clarify this contradiction. First of all, it should be clear that in the classical thermodynamics exist a dogma “When get flow of energy, you will have heating”. This is correct, but only

for homogeneous structures and media. Even the school boys know that biological systems and even organs are serious inhomogeneous structures. Here both biological and dielectric properties are different. How EMF heating occurs within complex biological structures? Therefore, absorbance of RF EMF will be different in different tissues, as well as the potential for temperature generation is different. The proponent of thermal approach never discuss the potential of flow of heat, especially in presence of blood and lymph circulation. And, in addition, what happens at the interface between tissues with different dielectric properties? What is the cascade of events, the alterations in the signal transduction and in the enzyme reaction rate?

I am physicist, but I know that for any biological or metabolic activity, the energy is needed. Why I should accept that in elementary biochemical processes, such as transport of ions through membrane or blood flow energy is needed, but heating (or more precisely overheating) had never been observed? Why we need to accept that the chemical factors can modulate biological activity without heating, but forbid this for physical factors?

The reported occurrence of hot spots in which temperature increase is significantly higher than in a neighboring cell cannot be explain by equilibrium thermodynamics. At the same time, nobody is capable to estimate the SAR alteration inside the human brain that results from RF EMF exposure and modulation. Here, one should introduce non-equilibrium thermodynamics in order to search for mechanisms of action, instead of classical, heat based, thermodynamics.

In addition, in order to understand the biological consequence of RF exposure, one must know whether the effect is cumulative, whether compensatory responses are present, and if or when homeostasis will break down.

On the other hand, there is a whole series of biologically important modifications that appear under weak static or alternating EMF action that could be explained only from the view point of non-thermal mechanisms. The spectrum includes changes at various levels: alterations in membrane structure and function, changes in a number of subcellular structures as proteins and nucleic acids, protein phosphorylation, cell proliferation, free radical formation, ATP synthesis, etc. [22–24].

Resonance mechanisms, frequency and intensity windows, as well as reports of modulated fields producing stronger or different effects than continuous-wave fields, and the presence of effects that occur at very low intensity could be indications of nonthermal effects and cannot be at all explained by SAR or thermal effects.

It is hard to understand why the papers on thermal mechanisms of high frequency EMF do not consider a set of parameters already pointed as important EMF characteristics [19, 25] such as vector, gradient, component, modulation, etc. but emphasize only on the SAR values.

In February 2018 the results of the US National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation confirmed increased cancer risk in rats and mice. In the cases of confirmed low-level microwave radiation effects, a mechanism other than tissue

heating should be involved. There is the justified demand for the clarification of the non-thermal mechanisms of the low-level microwave radiation effects. The most important result should be considered occurrence of gliomas in the exposed animals. Such effects had been reported in the number of epidemiological studies, but this is direct report obtained in the laboratory. Further studies need to be performed in order to determine if the effect is direct or indirect via affecting the mechanisms other than direct RF influence. I should point that one way or another, the fact that appearance of glioma in presence of RF radiation is direct confirmation of the hazard of RF EMF to initiate cancer, as it was said in 2011 by IARC As secondary effects of the NTP study were reported decline in body weight and benign tumors which might be regarded as alteration of the normal metabolism in exposed animals. In addition, an increased levels of damaged DNA could be interpreted as the effect of radiofrequency field on normal repair mechanisms. For me, very important is the observation that in some exposure conditions the animal's body temperature is slightly elevated (but less than thermal limit of 1 °C).

To continue our considerations, I would point that we had problems even with definitions of biological effects, health effects and health hazard. By misusing the terms, the scientific community has created havocs in discriminating what is a biological effect, what is a health effect and what is a hazardous effect. Unfortunately, this was further transferred in the language and terminology of the policy, standard and regulation bodies.

At the same time, the WHO policy is that “not every biological effect is a health effect”. This is not a correct definition. Obviously, by saying “health effect” WHO is considering the adverse effects in the sense of diseases, pathologies and injuries. The correct WHO statement should be “Not every biological effect initiated by EMF is a health hazard”. There is at least one reason for such statement: world-wide development of bioelectromagnetic medicine clearly indicates that properly chosen EMF/MF/EF and electric current may be beneficial in treatment of various diseases and injuries, even when all other known medical treatment dramatically failed [6, 7, 14].

There are several international (ICNIRP, ICES) and American (IEEE, ANSI) committees which more or less attempt to direct the world standards. However, even the simple fact of existence of several committees indicates the existence of a problem. It should be only one recognized and largely accepted standard institution which should substitute various national and international standards. Following this idea in the late 1990's WHO initiated a project involving different laboratories, standard organization and countries called “EMF Project of Harmonization of Standards”. Basically, nobody opposes such action, but everybody wants his standard to be in use. This, however, is the smallest problem.

The big problem is: Which standard, based on SAR which is the USA approach, or based on biological response, as many scientists from Eastern Europe and former Soviet Union requested. This is a problem with several faces: East vs. West; Biophysics vs. Engineering; Thermal vs. Non-

Thermal. What is curious, all three basically reflect to the last. Why is so?

Eastern standards are based upon biophysics (biological response) which assumes non-thermal mechanism(s). In contrast to the ICNIRP, the Russian safety standards for example, which are based on non-thermal effects, do not use SAR values but instead limit the duration of exposure and power flux density [26]. Western standards are based on engineering/computation and assume thermal mechanisms only.

As pointed out earlier, heat based mechanisms exclude possibility for occurrence of non-thermal effects. In a document adopted by the International committee of electromagnetic safety (ICES) cited by Cho and D'Andrea [27] "Nonthermal RF biological effects have not been established and none of the reported nonthermal effects are proven adverse to health. Thermal effect is the only established adverse effect."

It is interesting to know that the value of 100 W/m^2 (10 mW/cm^2) was proposed by the late Herman Schwan in his letter to US Navy in 1953 as a safe limit for human exposure to microwave energy, based on calculations [28].

Let me remind also the early statement of Becker [28] that "Based solely on calculations, the magic figure of 10 milliWatts per square centimetre was adopted by the air force as the standard for safe exposure. Subsequently the thermal effects concept has dominated policy decisions to the complete exclusion of nonthermal effects. While the 10 mW/cm^2 standard was limited to microwave frequencies, the thermal concept was extended to all other parts of the electromagnetic spectrum. This view led to the policy of denying any nonthermal effects from any electromagnetic usage, whether military or civilian".

The majority of the international and national guidelines for the exposure limits of health protection are still based on the recommendations of ICNIRP and take into account only thermal effects resulting in tissue heating (ICNIRP 1998). On the other hand, many studies in humans and animals have reported the biological and physiological effects of microwave radiation at the levels of exposure below the thermal limits. As Belyaev [10] pointed "At chronic conditions exposure to mobile phone may reproduce a number of real signals even during the same exposure session and thus provide a better possibility to assess detrimental effects from mobile telephony than experiments with fixed frequencies/frequency bands/modulations, which evaluate only minor part of real signals".

The ICNIRP guidelines for high frequency EMF (covering 100 kHz – 300 GHz) was established in 1998 – just at the time of the start of development of mobile communications. Since at this time research on GHz frequency region had began. The question arises – what are scientific bases for such standards. Moreover, in 2014 ICNIRP announced that a revision of the guidelines will be made, and just on December 7, 2017 the deadline was extended to the middle of 2018. Four years for revision of guidelines? It is not surprising that in the same note ICNIRP declares that "...the 1998 guidelines remains protective..."

and "...still provide protection against all known health effects of high frequency radiation...". What will happened with 4G and 5G technologies that industry aggressively distributes if the ICNIRP comes with a revision and being pronounced as hazardous? Will the standardization bodies follow the industry rules?

It is strange that on November 27, 2017 EMF-portal announced that "due to the lack of financial resourced the site have to suspend import of any new radio-frequency and mobile phone-related articles as of now. The portal will continue to import other EMF papers". For me, there is something suspicious here.

Being well-funded and responding to the interest of influential political, military and business circle, the supporters of thermal mechanisms of action prevail so far. For how long?

Let me make a step back and remind what late Ross Adey (2004) wrote in his last published when he was still alive paper: "Current equilibrium thermodynamics models fail to explain an impressive spectrum of observed bioeffects at non-thermal exposure levels. Much of this signaling within and between cells may be mediated by free radicals of the oxygen and nitrogen species". Cell signaling, signal transduction cascade and conformational changes are events and processes that may be explained only by the non-equilibrium thermodynamics. Even repeating myself, I would like to point on the importance of non-equilibrium thermodynamics in evaluation benefit and hazard of RF EMF.

Mobile communications and public health

Here I want to make clear that the potential hazard of the mobile communication is related more to the nonthermal effects of this physical factor (RF EMF), unknown to mankind until half a century ago. The cellular telephone delivers a power density of RF radiation that is 2 billion times greater than occurs naturally in the environment. The absorbed energy potentially could cause dangerous and damaging biological effects within human brain. Biological effects initiated by non-ionizing radiation could be achieved via conformational changes of important biological molecules (proteins, nucleic acids) and structures (as biological membranes) directly or via signal transduction pathways.

Let me remind several old, already forgotten studies. One of the first papers on the absorption of electromagnetic energy was published by Schwan and Piersol [29], in which the absorption was connected to the tissue composition. It is important to note once again that the composition of living tissues is a very complex and varies from organ to organ, from person to person. From biophysics point of view, the energy absorption also depends on the depth of penetration for the specific frequency range (for 825–845 MHz the penetration depth into brain tissue is from 2 to 3.8 cm) [5].

Forty five years ago, Michaelson [30] wrote "It should be understood that a cumulative effect is the accumulation of damages resulting from repeated exposures each of which is individually capable of producing some small

degree of damage". In other words, the repeated irritation of a particular biological area, such as a small region of the brain, can lead to irreparable damage.

If a "hot spots" was formed, a rapid energy absorption will have maximum destructive effect because, as shown by Lin [31], very little of the absorbed heat will have an opportunity to dissipate: "Because, microwave absorption occurs in a very short time, there will be little chance for heat conduction to take place."

Back to today situation. The EMF effects on human tissues and human brain specifically, are strongly related to the tissue dielectric properties. However, these dielectric properties are basically not well known for human brain, and especially for children brain. To better understand the problem with the hazard of RF EMF for human brain will be useful to consider the structure of the human head. It is known that human head is a complex structure of many different tissue types. Each of the tissues – skin, bone, cerebrospinal fluid, fat, brain, dura absorbs and reflects RF energy in its own way. In addition, the human head is far from having uniform shape, volume, and structure. Therefore, the RF EMF interact with human head in a non-uniform way depending on the specific location of the brain areas/volumes.

Some of the interior "hot spots" in the brain are related to the radius of curvature of the human head. First, one should recognize that human head is far from the ideal spherical shape that is used in the modeling. It is easy to assume that the radius of the curvature is different for baby, little child, teenager, or adult individual. The energy absorption within the brain tissue was found to be about twenty times greater than in the skull and subcutaneous fat.

At these "hot spots" the heating is rapid and the cooling is slow. The inability of biological tissue to get rid of excess heat quickly and efficiently may be mechanism leading to destructive exposure. If "hot spots" occur at microscopic regions within the brain, where there are no thermal or sensory receptors, there is no reason to expect that the body will attempt to compensate for the overheating. In addition, the human brain simply does not have the capacity to prevent the damage.

Let consider the structure of the heads of children and smaller adults. The curved area behind and above the ears is more severe, and the total width of the head is correspondingly reduced. Since "hot spots" absorption is a function of head curvature, children and some adults are more susceptible to this type of "hot spots" formation. Long before the introduction of cellular telephones, scientists obtained data indicating that children absorb approximately 50 percent more radiation within their heads than adults [32]. Lin in 1977 placed the increased absorption effect into a better perspective when he reported that "hot spots" energy absorption can be as much as ten times higher at certain areas within the brain. From experiments performed using models of the human head, he reported energy absorptions in the center of the head that were even higher than absorption levels near the surface [33]. This is a prime example of "hot spots" energy deposition.

The presence of nonuniform energy absorption that treated the new type of "hot spots" was initially characterized by Schwan in 1972. He suggested that as head diameter is smaller, the energy absorbing "hot spots" become more pronounced. The research found that for heads significantly smaller than that of a mature man, the "hot spots" effects increase and so does the amount of energy that is absorbed into the interior of the brain. Clearly, this indicates an increased risk of "hot spots" absorption within the brains of women and children, with small children being at maximum risk a "hot spots" absorption within their brains. It had been also reported by Schwan that maximum "hot spots" energy absorption occurs in the frequency region around the cellular telephone frequencies [34, 35]. There were no cellular telephones on the market at that time.

It was reported that "for human brain exposed to 918 MHz power, the absorption at a depth 2.3 times the depth of penetration (depth of penetration = 3.2 cm) is twice the absorption at the surface. This corresponds to a factor greater than 200 times that expected". This means that at a depth within the human brain of about 7 cm, "hot spots" have energy absorption 200 times greater than would be the case if no "hot spots" existed.

Interestingly enough, the Parliamentary Assembly, Council of Europe, in its Resolution 1815 from 2011 recommends to "reconsider the scientific basis for the present electromagnetic fields exposure standards set by the ICNIRP, which have serious limitations and apply "as low as reasonably achievable" (ALARA) principles, covering both thermal effects and not thermal or biological effects of electromagnetic emissions or radiation" [36].

Last summer more than 180 prominent scientists from Europe, North America and Asia send an appeal to European Parliament to forbid distribution of 5G technology on the territory of European Union at least until strict evaluation of the potential hazard of millimeter waves technology is made.

The end of 2017 and the first months of 2018 demonstrated the aggressive development of 5G technology. Jiang et al (2018) wrote in Microwave Journal that the information and communication industry is facing great change due to the rapid development of applications leading in explosive growth in data traffic [37]. The 5G technology roadmap consists of two parts & a new air interface and evolution of 4G air interface [38]. In a long, well written paper are described all avenues of development and manufacturing all aspects, achievement and planning for the 5G technology. No word about the potential impact on human health.

Protect children

It is important that not only the public health community, but every citizen of this planet recognize that for the first time during the whole period of civilization, the massive electromagnetic radiation reaches our future – children. Children and adolescents are exposed for long hours every day to conditions which makes the potential risk to the health of children very high [39, 40]. At the 2001 WHO meeting on harmonization of standards,

I made a statement that allowing little children to use the cell phones is a crime against humanity [41]. I believe that it is still valid statement.

In most cases the publications on the RF EMF hazard for children are based on epidemiological data collected by some surveys and quite frequently without having direct contact with children or their parents. Therefore, this approach brings the issues to statistics, not to science. Obviously, epidemiological studies basically do not relate to biology, to the process of occurrence of one or another modification of the living tissue.

On the other hand, the situation is complicated by the attempt to model children head based on adult heads. There are several models scaling adult models down to children heads which appears to be wrong. This approach does not account geometrical differences, and what is more important, the anatomical and physiological differences between adult brain and developing brain of a child. Nikita and Kiourri (2011) published barograms that express 37 % difference in local SAR for adult and child brain. If the data really present SAR for brain of adult and child – in accordance of the engineering approach, these values should be similar. If not – as the case is – it means that the scaling exercises should be forgotten and forbidden [42].

However, the same authors stated that “in the case of canonical models, the child model is perfectly proportional to an adult model”. This is possible only in theoretical (more likely mathematical) modeling when no one take care about the specifics of geometry, composition, and development of children head and brain. It is even written that Koulouridis and Nikita (2004) obtained children model through uniform deformation of spherical adult head models [43]. I should remind the authors that neither adult head is spherical, nor the brain composition of adult and children is homogeneous.

Several publications on cell phone dosimetry in children reported higher SAR for children brain which is correctly attributed to geometrical difference in the head of children and adults [44, 45]. Scientists working in the dosimetry areas proposed different explanations for the fact that different laboratories concluded that SAR in children brain is higher, smaller or equal to the SAR in adult brain.

It is well accepted that human head is composed by six layers: skin, subcutaneous fat, skull, dura, cerebrospinal fluid, and brain tissue. A total thickness of the five layers that surround the brain is assumed as 1.10 cm. However, we must keep in mind that the layers could vary significantly from one human head to another. What is more important, the proportion of these layers changes during the child aging. As the models become more complex and increasingly representative of an actual human head, the findings continue to indicate that the energy absorption is much higher than previously thought.

The range of sizes includes almost all human heads. It is clear that what was first observed as a danger to those with smaller cranial structure, and most notably including children, has been extended by additional studies to include nearly all humans. Of course, the most dramatic “hot spots” peaks are within the smaller heads.

It would be plausible to point the Russian experience in studying the hazard of the RF EMF for children and the legislation on this direction. In 2001 the Russian National Committee for Protection from Non-Ionizing Radiation recommended that children under age of 18 as well as pregnant women will not use mobile phones. These recommendations further had been incorporated in the Hygienic Norms for EMF of mobile communications (SanPin 2.1.8/2.2.4.1190-03, valid from 2003). In 2004 Grigoriev suggested that precautionary principle must be applied for evaluation of hazard for children. Beginning 2006 a number of studies of RF EMF effects on children have been conducted in Russia. These longitudinal studies of effects of microwave radiation were oriented mainly to evaluation of the cognitive functions of different age children by using a complex of psychophysiological tests. It has been detected an increase in the time of the reaction to light or sound signals, disturbances in the phonematic association, decrease of the work ability, faster occurrence of fatigue, increase of time for completion the task with simultaneous decrease of accuracy [40, 46].

Since the industry and unfortunately, the scientific community, do not have appropriate care for the health of children, the responsibility is on parents. Look what happened: Children in kindergarten or primary school are considering mobile phone as a nice toy and play hours and hours with it. At that age their body and more important their brain is not yet developed. Who may be so brave to claim that the use of mobile phone at that age is not dangerous? Who may predict what would happen with these “users” 20–30–50 years later?

As WHO postulated, we should know that children are more sensitive to all factors of the environment than the adults: “Children differ from adults. Children are uniquely vulnerable when they grow and develop, they have “windows of susceptibility”: periods when their organs and systems, perhaps especially sensitive to certain environmental factors” [47]. Therefore, it should not be doubt that developing brain is exposed to increasing irradiation during the formation of higher nervous activity. The society, in general, and scientists, in particular, should not forget this.

One thing that wonders me when I listen or read the epidemiologists papers on children exposure to RF radiation is that the authors do not recognized that the cancer does not occur overnight and that there is slow accumulation of damages that after certain time may turn in dangerous direction.

It is disturbing to read “These studies have not provided any sign that RF EMF emitted by cellular phones increases the chance for carcinogenesis” [42]. I certainly do not think that this statement is correct. With the risk to be confronted from epidemiologists, I definitely disagree with their statement “there is no conclusive and consistent evidence that nonionizing radiation emitted by cell phone is associated with cancer risk” [48]. It is remarkable that this paper was published after IARC defined RF as “possible cancerogenic for humans”. In another paper [16] discussed the fact that the long-delayed publication of

the INTERPHONE data resulted in the strange situation: two groups of participants in this project published two papers that basically contradict each other. This is another confirmation that the conclusion of epidemiological studies should not be accepted as absolute, especially that in most cases the studies are funded by the industry. The epidemiological community surprised by the IARC classification of the RF microwave as possible cancerogene. Interestingly enough, number of studies had pointed out that electromagnetic energy in the 900 MHz region may be more harmful because of its greater penetrating capability compared to 2,450 MHz, therefore more energy in the 900 MHz frequency range is deposited deeply within biological tissue. In 1977 Lin concluded that 918 MHz energy constitutes a greater health hazard to the human brain than does 2,450 MHz energy for a similar incident power density [31].

Let me remind that studies of diathermy applications consistently show that electromagnetic energy at frequencies near and below 900 MHz is best suited for deep penetration into brain tissue. The depth of penetration is noticeably greater at this frequency range, which includes the cellular phone frequencies as compared with higher frequencies. What is also important is the proven fact that deep tissue heating is obtained without detecting significant heating in the surface tissues. High absorption in inner tissue such as the brain occurs while fat and bone absorption is many times less.

The manufacturers of diathermy devices are obliged to indicate the maximum safe distances and directions that must be maintained by therapists. Of course, if there must be defined some safe distance to be maintained from devices emitting 5.0 mW/cm², then certainly we might expect some safe distance to be kept from devices emitting higher levels of RF radiation – portable cellular telephones. This should be especially true when suggesting the spacing between the portable device and human head, respectively, to the human brain.

Since the human brain has little, if any, sensory capability, damage or trauma occurring internally will not be felt until the heating is severe and already cause some damaging effects. The threshold for irreversible skin damage is about 45 °C which is also the temperature at which pain is felt. So, by the time a person, exposed to RF radiation, feels pain at the skin that skin is irreversibly damaged, as is the deeper tissue beneath the skin. Similarly, internal heating of brain tissue would not be sensed as a burning sensation. Likely, there would be no sensation at all. Interest in the ability to “sense” the presence of high levels of RF radiation motivated researchers to determine threshold levels for detecting heat sensations due to radiation exposure [49].

Considering the lack of sensory detectors in the brain, we can expect that no warning of brain tissue destruction would be provided to a cellular telephone user until the damage was so extensive that the scalp, which absorbs very little energy, sensed heating. One of the problems that need to be stressed is that the brain did not absorb the energy uniformly.

The Future

As it was shown, the XXI century exponentially increases the use of electromagnetic polluters in sense of exposing the mankind and entire biosphere to various electromagnetic fields. No control, no interest from the side of WHO and public health offices. At this moment nobody knows what potential effects of these polluters are. Even the IARC classification that the microwaves used in cellular communications are potentially hazardous addresses only one small fraction of the entire spectrum. If the public health system abandons this field, the industry is here. With more and more items.

Just two examples from recent development. The “smart meters” became installed in each house with the purpose to provide minute by minute information about the use of electricity by various home utilities and electronics. Effectively, industry installs small radiostations in each house. What will happen with inhabitants of the house – industry does not care. What will happen with biosphere as result of billions of transmitters – nobody care.

Google lounged “smart glasses” in May 2014. The owners of this quite expensive toy will be able to use Field Trip instructor, translator Word Lens, Google Now, Google maps. The owner will be able to participate in conversation and even conference calls, to make videos, etc.

A problem that is not new, but escaped from the horizon of scientists and public health experts: electrical vehicles. These type of cars needs electrical power to charge the high capacity batteries as well as this battery will be a driving force for the vehicle. Did somebody analyzed the electromagnetic fields inside the vehicle?

Something even more troublesome: it was reported that now are already developed “magnetic bacteria” that could be incorporated in probiotic bacteria and be used as a tool for diagnostics and therapy of diseases of internal organs.

It is time now to ring the bell. This probably will not be enough. Scientific and medical communities must stand opposing uncontrolled introduction of toys and tools that utilize electromagnetic fields.

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Электромагнитные поля в биосфере: преимущества и опасность

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Обобщена роль электромагнитных полей в происхождении и эволюции жизни на Земле, а также рассмотрены опасность и польза электромагнитных полей (ЭМП). Попытка показать, что сегодня человечество и вся биосфера подвергаются глобальному эксперименту, проводимому без программы и мониторинга. Было доказано, что ЭМП являются полезными для лечения различных заболеваний. Однако развитие передовых коммуникационных технологий из года в год увеличивает опасность для биосферы и человечества. В статье обсуждаются противоречия между учеными и инженерами-технологами по эффектам термических или нетепловых воздействий ЭМП. В конце второго десятилетия XXI в. в Северной Америке и Европе вводятся более агрессивные мобильные коммуникации, такие как 4G и особенно 5G, без какой-либо попытки оценить опасность для цивилизации. Анализируются конкретные проблемы со здоровьем детей, пользователей сотовой связью.

Древние медики в Китае, Японии и Европе применяли природные магнитные материалы для лечения различных заболеваний. После Второй мировой войны магнитотерапия быстро развивалась в Японии, а затем в Румынии и в бывшем Советском Союзе. Магнитотерапия имеет долгую историю в Европе. В 1960–1985 гг. в большинстве европейских стран были созданы магнитотерапевтические системы. Первым клиническим применением электромагнитной стимуляции в США было в 1974 г. [2]. Первая книга по магнитотерапии, написанная Н. Тодоровым, была опубликована в Болгарии в 1982 г. Вторая половина XX в. знаменует значительный рост клинического применения ЭМП. Автор напоминает, что в этот период серьезный вклад был сделан советской наукой. Почти каждый год проводились по меньшей мере две всесоюзные конференции. Некоторые из них привлекали ученых из европейских стран. Были организованы и некоторые международные проекты. В течение почти 10 лет в СССР активно функционировала Национальная комиссия по магнитобиологии и магнитотерапии с целью стимулирования развития этих двух областей. В 1989 г. во время первого советско-болгарского симпозиума в Болгарии была создана Ассоциация магнитологии.

В последнее десятилетие исследования были сосредоточены, главным образом, на изучении опасностей сотовой телефонной связи. ВОЗ признало важность этой проблемы, был создан Международный проект ЭМП, главной целью которого было согласование стандартов для излучения и воздействия ЭМП. В течение последних двух десятилетий ВОЗ организовала серию международных совещаний в разных точках мира с целью согласования стандартов. К сожалению, эта деятельность не закончилась определенными рекомендациями. Международное агентство по исследованию рака (IARC) признало, что ЭМП сотовых телефонов обладают возможным канцерогенным действием (категория 2B). Существует большое количество результатов фундаментальных исследований и клинических доказательств того, что ЭМП, изменяющиеся во времени, могут модулировать молекулярную, клеточную и тканевую функции. Каскад сигнальной трансдукции позволяет биологически реагировать на воздействие ЭМП простым структурам, таким как клеточная мембрана или специфические белки, конформационные изменения и/или перераспределение зарядов. В работе русского ученого И. Беляева подчеркнута, что биологические системы являются не только нелинейными, но и неравновесными системами [10].

XXI в. отмечен экспоненциально растущим развитием технологий беспроводной связи. К непрерывному действию сложных и неизвестных (по источникам, амплитудам, частотам) электромагнитных полей подвергается полная биосфера и каждый организм, живущий на этой планете [9]. Известно, что сотовый телефон (СТ) обеспечивает высокую плотность мощности радиочастотного (РЧ) излучения, что примерно в 2 миллиарда раз больше, чем аналогичные поля, которые естественным образом возникают в окружающей среде. Большая часть энергии излучается непосредственно в мозг пользователя СТ.

Опасность высокочастотных электромагнитных полей, используемых в коммуникациях XXI в., часто обозначается как «противоречивая», и это абсолютно неверно. Это не спорный вопрос, это конфликт интересов промышленности с одной стороны, и человечества и окружающей среды – с другой. Автор считает, что особое внимание следует уделить потенциальному ущербу, который общество XXI в. наносит детям. Это реалии нашей жизни, и теперь невозможно защитить детей от «коктейлей» электромагнитных излучений. Дети – самая агрессивная часть пользователей беспроводных устройств – игрушек, планшетов, смартфонов [16]. И что самое худшее, их тело и мозг стали подвержены воздействию радиочастотных ЭМП почти с момента их рождения, и в большинстве случаев дети начинают использовать компьютерные игрушки уже в возрасте от одного года. Воздействие ЭМП РЧ на новорожденных будет более продолжительным и сильным, чем воздействие на родителей.

К сожалению, регулирующие органы состоят только из инженеров, юристов, деловых людей. Эксперты в области здравоохранения отсутствуют. Руководители отрасли, инженеры и специалисты по дозиметрии постоянно искажают вопросы, связанные с потенциальной опасностью излучения СТ. Инженерные комитеты ICNIRP и IEEE продолжают вводить в заблуждение научные и медицинские сообщества, а также широкую общественность в том, что единственно значимые эффекты ЭМП являются только термическими.

Следует отметить, что биологические системы являются нелинейными системами. Многие биофизические исследования показали, что в лабораторных и клинических условиях преобладают нетепловые эффекты [12]. Нетермический характер взаимодействия между ЭМП и живыми системами обсуждался в других публикациях [10, 14, 18].

Автор считает, что две новые технологии модальности 4G и 5G открывают большие окна для распространения потенциальной опасности на биосферу и человечество.

После более чем четверти века использования ЭМП научное и медицинское общество не понимает, до какой степени ЭМП от мобильной связи представляют собой угрозу для населения. В худшем случае, по мнению автора, отсутствует идентификация условий и параметров ЭМП РЧ, при которых облучение населения этими микроволнами становится хроническим. Население подвергается этому излучению без каких-либо знаний об экспозиции или параметрах ЭМП. Автор считает, что международная система контроля и регулирования потерпела неудачу. Вопрос в том, есть ли теперь реальный контроль. Что исследователь знает о добровольном облучении, полученном до исследования или даже во время исследования из окружающего источника ЭМП? Новые технологии приведут всю биосферу и цивилизацию к новым уровням электромагнитного загрязнения, которые не определены, для которых нет стандартов и методов контроля. Для того, чтобы понять биологические последствия воздействия ЭМП РЧ, необходимо знать, является ли эффект кумулятивным, имеются ли компенсаторные ответы, и если или когда гомеостаз будет разрушаться.

В статье рассматриваются результаты Национальной программы токсикологии США по изучению канцерогенеза радиочастотного излучения сотовой связи, которые подтвердили повышенный риск развития рака у крыс и мышей (2008). Важнейшим результатом двухлетнего эксперимента считается появление глиом у облученных животных. По мнению автора, факт появления глиомы после хронического воздействия ЭМП является прямым подтверждением опасности ЭМП РЧ для инициирования рака.

Существует несколько международных (ICNIRP, ICES) и американских (IEEE, ANSI) комитетов, которые более или менее пытаются разработать мировые стандарты для воздействия ЭМП РЧ. В 1990-х гг. ВОЗ инициировала проект «Гармонизация стандартов ЭМП» с участием организации и ученых из различных стран. Говоря условно, большая проблема заключается в следующем: Восток против Запада. Восточные стандарты основаны на биофизике (биологической реакции), которая предполагает нетепловой механизм. В отличие от ICNIRP, российские стандарты основаны на нетепловых эффектах, а западные – на термических механизмах. Руководящие принципы ICNIRP для высокочастотной ЭМП РЧ были установлены в 1988 г., в период начала развития мобильной связи. Более того, в 2014 г. ICNIRP объявила о пересмотре руководящих принципов, в декабре 2017 г. срок был продлен до середины 2018 г. Автор статьи удивлен, что в ноябре 2017 г. ЭМП-портал объявил, что «из-за нехватки финансовых ресурсов сайт должен приостановить получение любых новых статей и документов», тем самым ICNIRP приостановил свою работу.

Важно, чтобы каждый гражданин планеты признал, что впервые за весь период цивилизации массовое электромагнитное излучение действует на наше будущее – детей. Дети и подростки ежедневно подвергаются воздействию факторов, которые делают возможным высокий риск для здоровья детей [39, 40]. На совещании ВОЗ в 2001 г., посвященном гармонизации стандартов, автор статьи сделал заявление о том, что предоставление детям разрешений на использование сотовых телефонов является преступлением против человечности [41]. Мозг ребенка поглощает энергию в два раза больше, чем у взрослого пользователя. В большинстве случаев публикации по воздействию ЭМП на детей основаны на эпидемиологических данных, собранных в ходе некоторых обследований, и довольно часто без прямого контакта с детьми или их родителями. Поэтому такой подход нельзя назвать научно обоснованным.

Автор статьи отдельно остановился на российском опыте изучения опасности ЭМП РЧ для детей и о законодательстве в этом направлении. В 2001 г. Российский национальный комитет по защите от неионизирующего излучения рекомендовал, чтобы дети в возрасте до 18 лет, а также беременные женщины не использовали мобильные телефоны. Эти рекомендации были также включены в гигиенические нормы для ЭМП мобильной связи (СанПиН 2.1.8 / 2.2.4.1190-03, действующие с 2003 г.). В 2004 г. Ю.Г. Григорьев предложил применять принцип предосторожности для оценки опасности ЭМП для детей. Начиная с 2006 г., в России проведены многолетние исследования влияния ЭМП РЧ на детей. Эти долговременные исследования эффектов микроволнового излучения были ориентированы в основном на оценку когнитивных функций у разновозрастных детей с помощью комплекса психофизиологических тестов. Обнаружено увеличение времени реакции на световые или звуковые сигналы, нарушения в фонематической ассоциации, снижение работоспособности, более быстрое возникновение усталости, увеличение времени выполнения задачи с одновременным снижением точности [40, 46].

Кто может предсказать, что произойдет с этими пользователями через 20–30–50 лет? Как постулировала ВОЗ, мы должны знать, что дети более чувствительны ко всем факторам окружающей среды, чем взрослые: «Дети отличаются от взрослых. Дети становятся особенно уязвимыми, когда они растут и развиваются, у них есть «окна восприимчивости»: периоды, когда их органы и системы, возможно, особенно чувствительны к определенным факторам окружающей среды» [47]. Поэтому не должно быть сомнений в том, что более опасно, когда развивающийся мозг подвергается облучению ЭМП при формировании высшей нервной деятельности.

В настоящий момент никто не знает, какие потенциальные последствия возможны при этих техногенных загрязнениях среды обитания населения. Нет никакого контроля, никакого интереса со стороны ВОЗ и учреждений общественного здравоохранения. Пришло время звонить в колокол (М. Марков).

Ключевые слова: электромагнитные поля, мобильная связь, здоровье населения, защита детей

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