

Biophysical Properties of Liquid Water Exposed to EM Radio Frequency Radiation

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1. Introduction

Water is the most abundant substance on the surface of the earth and is the main constituent of all living organisms. The human body is about 65 percent water by weight, with some tissues such as the brain and the lung containing nearly 80 percent. Without water life would probably never have developed on our planet (Mottl et al., 2007). Increasing evidence indicates that the water has unique electromagnetic and biophysical peculiarities (Ball, 2001; Voeikov & Giudice, 2009). Since all life is based on water, all molecules in the living organisms interact with water. The water of body may not only be a carrier for nutrition and energy, but also a source and carrier for regulating electromagnetic information (Pan, 2003). Human and animal beings are bioelectrical systems and they are regulated by internal electromagnetic (EM) signals, which form an endogenous EM field. Environmental exposures to the artificial EMFs can interact with fundamental biological processes in living organisms. It is supposed that the environmental exposures to natural and artificial EM fields may interact with biological EM signals through intracellular and extracellular water. In some cases, this may lead to disease. During the past twenty years, the growing use of mobile phones (MP) has aroused great concern regarding the health effects of exposure to the EMR (Kundi et al., 2004, Khurana et al., 2009). Dual-band phones can cover GSM networks in pairs such as 900 and 1800 MHz frequencies (Europe, Asia, Australia, and Brazil) or 850 and 1900 MHz (North America and Brazil). Today's public exposure limits for telecommunications are based on the presumption that heating of tissue is the only concern when living organisms are exposed to EM radiation. In the last few decades, it has been established that bioeffects occur at non-thermal or low-intensity exposure levels thousands of times below the levels that state agencies say should keep the public safe. As reviewed in (Genuis, 2008), there are several hundred studies that support the existence of low-intensity, non-thermal effects of the MP radiation on biological systems. The consequences are mostly adverse: DNA single- and double-strand damage, changes in gene transcription, changes in protein folding, heat shock protein generation, production of free radicals, and effects on the immune system. In addition to mobile phones, new communicating systems are in use and developments of higher frequency applications are to come.

At present the question how such a low-energy of EMR could influence the functional activity of cell and organism still remains unanswered. Numerous hypotheses on molecular mechanisms of the specific biological effect of EMF have been proposed, but none have

provided a reliable and exhaustive explanation of the experimental findings. The absence of such a mechanism cannot be taken as proof that health effects of environmental electric and magnetic fields are impossible. As water is the main medium where the major part of biochemical reactions is taking place, it is supposed that the environmental exposures to natural and artificial EM fields may change metabolic activity of cells and organisms using body's water as a primary receptor of the EM field (Shalatonin, 2008, 2009). Increased knowledge of the mechanisms underlying electromagnetic information storage, amplification and transduction by water may give us a fundamentally new comprehension of the processes operating in the water within biological systems (Del Giudice et al., 2010).

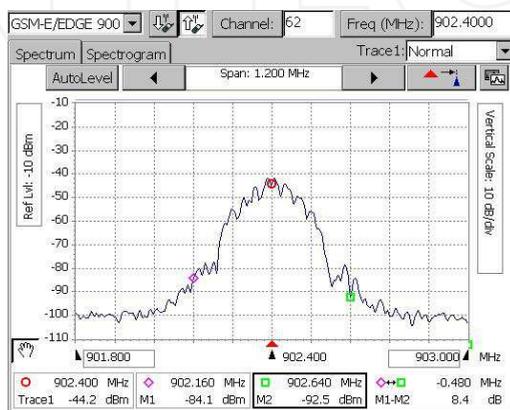
This work presents simple and sensitive biophysical experiments and its results to develop our notion that a possible reason of the long-term physical changes in water is conditioned by internal structures of the oxygen and hydrogen nuclei and the quantum properties of the EM radiation (V. Shalatonin, 2009, 2010, 2011; Shalatonin & Mishchenko, 2010).

2. Objects and methods

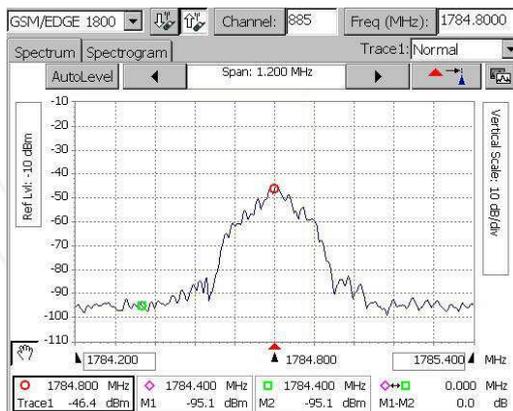
The main objects of these experiments have been wheat grains and drinking bottled artesian water. The grains were chosen to have a middle quality in order to have possibility to increase or to decrease its developmental properties. The water for their watering was preliminarily being exposed to the pulse-modulated EM radiation from GSM MP type Nokia, which was connected to a personal computer through an interface cable. The MP parameters were controlled via the nokia service program WINTESLA in order to change power, carrier frequency and other parameters of the EM radiation. The experimental setup is shown in Fig. 1. It consists of an appropriate glass with water which is located 5 - 6 cm away from the MP antenna. A dual-band phone, which can cover GSM-900 and GSM-1800 networks, was used. GSM-900 uses 890-915 MHz to send information from the mobile phone to a base station, providing 124 RF channels (channel numbers 1 to 124) spaced at 200 kHz. Frequency band of GSM-1800 is 1710-1785 MHz, providing 374 channels (channel numbers 512 to 885). The GSM standard employs the time division multiple access (TDMA) technique with eight time slots. This means that the transmitter is only ever switched on for an eighth of the time. Eight GSM phone users can share a pair of 200 kHz wide-band channels, because each user is given access only to a single 576 μ s time-slot in a 4.6 ms frame, which is repeated 217 times a second. This 217-Hz cycle of power pulses is in the range of the normal bioelectrical functions both in and between cells, so it may induce low frequency power surges, causing health problems. The transmission average power in the phone is limited to a maximum of 2.5 watts in GSM-900 and 1 watt in GSM-1800. The typical radio spectra of the emitted EM radiation are shown in Fig. 2. They were measured by using a spectrum analyzer Tektronix Y400 NetTek Analyzer. The exposure time was 1.0-1.5 hour at an average power density of 55 μ W/cm² (GSM-900) and 1.7 μ W/cm² (GSM-1800). The power density was measured by a power meter P3-41 shown in Fig.1. Its antenna while measuring the power density at the same position as a water sample was installed. Pondus hydrogenii (pH) values of the water samples were determined by a pH meter (HI 9341, HANNA) with a precision of 0.06 pH units. A radiofrequency generator G4-76A was also used in our experiments.



Fig. 1. Photo of the experimental model



a



b

Fig. 2. Power spectra of the MP electromagnetic radiation: a – GSM-900; b – GSM-1800

3. Results and discussion

3.1 Biological properties of the water exposed to the GSM-900 MP radiation

Two samples of water, one of which was exposed to mobile phone EM radiation and the second one was the same but with regular water were used for watering the equal amount of wheat grains placed in two equal cups (200 grains in each cup). The quantity of the grains in each cup and its watering were equal throughout the experiment. New exposed water samples were being prepared in the same way once a day during the experiment. It should be noted that a first watering was being carried out in approximately 30 minutes after the exposure. The analysis of the quantity of the sprouted grains and the level of their development showed the significant differences for the sprouts in different cups. In Fig. 3 and Fig. 4 the most typical results and photos are given.

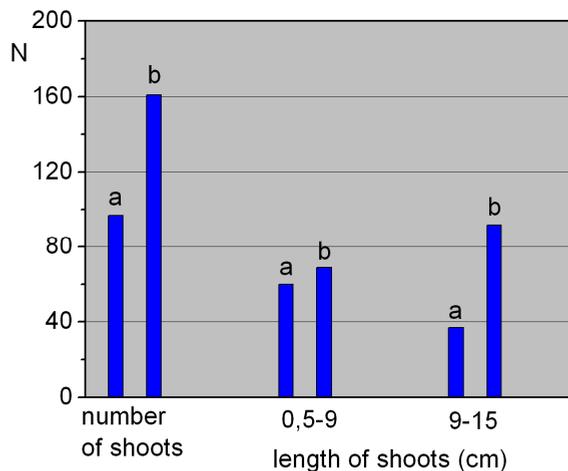


Fig. 3. Number and length of the sprouts for two groups of wheat grains are shown. The MP operated at a carrier frequency of 902. 4 MHz (62nd uplink channel of GSM-900). The experiment was conducted from March 12th to March 20th, 2010

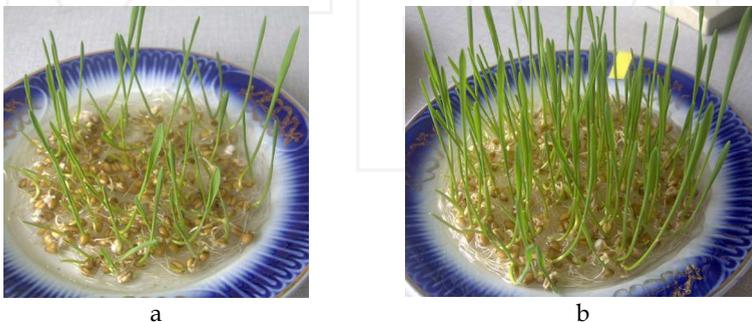


Fig. 4. Photos of the sprouts: a – watering with the ordinary water; b – watering with the exposed water. The 8th day of the experiment

The level of development and quantity of the appeared shoots were significantly better for the grains watering with the exposed water. It can be seen in Fig. 3. The differences indicate that the EM radiation induced the stable changes in a physical state of the exposed water. The exposed water became more active and increased the grains vitality. A similar changes but not so expressive were observed in subsequent experiments, carried out for some other channels of the GSM-900 MP radiation.

It should be noted that in our experiments we wanted not only to find new results, connected with the ability of the exposed water to play an essential role in vital processes of wheat or other grains. Best of all we would like to get new data related to our approach for explaining the ability of water to store the EM or other kind of information. Therefore, let us explain the next step in the direction of our experiments (Shalatonin, 2011a).

At present most of proposed ideas devoted to this problem are being based on the molecular level of water and closely connected with the water clustering. But these results can not explain how the non-thermal magnetic and EM fields could essentially affect the hydrogen bonds in water during clustering. According to Ben-Jacob (2010) "... the detailed molecular-level properties of water are very important. Yet, it is becoming evident that they are not sufficient to provide a complete theory of water; we are missing some essential water aspects that cannot be accounted for by the molecular level investigations irrespective of how detailed and sophisticated they will be". We suppose that we are missing not only some essential water aspects but we are also missing essential properties of EM radiation, without which it is impossible to explain the phenomenon of water. Especially those related to the endogenous EM field from living beings.

Jerman et al., (1996) examined the possibility that ultra weak supposedly EM emission from living beings (bio-field) changes the structure of water. The results showed that normal seeds given water exposed to dying spruce seedlings reacted with significant slowing of germination and had a tendency to grow more slowly than controls (watered by ordinary water). This line of experiments demonstrates indirect evidence for some form of endogenous ultra weak EM emission from living beings. The authors pay attention that such emission alters water in some as yet unknown way, and that organisms can influence each other through indirect non-chemical and perhaps electromagnetic alteration of water. Slovenian scientist Detela (2002) considers that the bio-field is a subtle material structure which is permeating biological cells of living beings. It is assumed that bio-field is a three-dimensional web woven of vibrating electric and magnetic fields. Such structure of the bio-field is in close correspondence with the molecular structure of living organisms and interacts with discrete atoms and molecules in living cells. Therefore this field can regulate many processes in living organisms. Its structure must remain temporally stable and its energy must not be dissipated. In a simplified way, it can be imagined the bio-field as a "cloud" that is asymptotically approaching a zero-value in all regions that are distant from the cloud centre. Such a field pattern is a type of steady wave packet and could be described by using modified Maxwell equations. In agreement with this theory, the presence of an unusually sharp border of the electric field in the space around living organisms has been detected (Shalatonin, 2007). The main objects for measurements were some of the flower plants including roses and carnations. The sections of the field ("cloud?") surrounding flowers are shown in Fig. 5 and in Fig.6. The author concluded that possibly in the space around

living beings there is a region of the bio- field (inside of the detected border), and the region of the bio-radiation, which extends beyond the detected border. It reminds to some extent the EM field structure of an ordinary antenna. Indeed, it is well known that every EM antenna has three areas: near, intermediate, and distant. The near EM field does not participate in a process of radiation but in the distant area the magnetic and electric components of the EM field are in phase and the EM radiation is created. Coming back to the paper of Jerman et al. (1996) one can assume that just this bio-field could be a source of the information for water samples located near dying spruce seedlings.

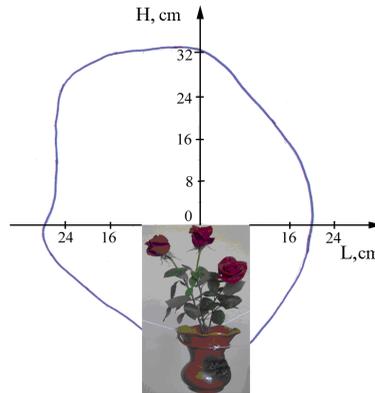


Fig. 5. The boundary of abrupt change of the electric field, surrounding the three red roses

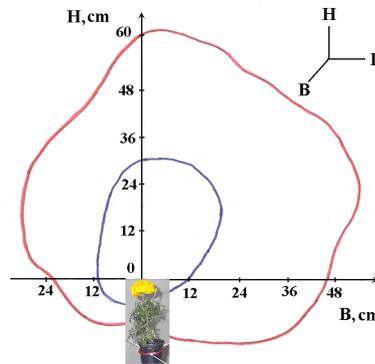


Fig. 6. The boundary of abrupt change of the electric field, surrounding the tagetes erecta:
 — in the morning;
 — in the evening

The obtained results, which we have just discussed, show that the EM field in our opinion is probably not an original field, which is responsible for the exchange information between water and bio-objects and between different bio-objects. Therefore, we support a notion (not a new one) that every kind of radiation including the EM one is with a still unexplored component. We suppose that this biologically active physical component arising due to the EM radiation is possibly the same kind of radiation as the radiation from bio-objects. It is

possibly that just this radiation is responsible for the appearance of long term changes in water. In order to simplify referring to this kind of radiation it is convenient to call it as the active informational radiation (AIR) and then some particles, which correspond to this radiation, could be called as aions.

Now, we still have no real possibility to measure parameters of this radiation. Therefore, it would be useful to find something working like the presence indicator. We tried to find some materials, which, being placed between a mobile phone and a water sample could change (modify) the above discussed component of the EM radiation and this, in turn, could lead to a significant change in biological properties of the water, exposed by this changed AIR. In other words, we tried to define the presence of some factor of the EM radiation (that is the AIR), which is responsible for the water long term activation. It is important that the well known measurable EM radiation should not be shielded by these materials. Therefore, in our experiments metallic shields were not used. When choosing the suitable material, we have learned that several layers of an ordinary polyethylene film (PF) are able to modify or to shield such kind of radiation (Veinik, 1991). The polyethylene $(-\text{CH}_2-\text{CH}_2)_n$ is an unusual solid in that it solidifies in long, kinked chains consisting of individual CH_2 units. It is essential that a polyethylene is a low dielectric loss polymer and so can not shield and even considerably change an intensity of the EM radiation. It was supposed that the PF placed between the MP and a water sample could change (modify) the AIR and the biophysical properties of the water samples influenced by this radiation. The experiment was conducted from March 23rd to March 31st, 2010. The MP operated as earlier at a carrier frequency of 902, 4 MHz (62nd uplink channel of GSM-900).

Let us describe this experiment in details. In Fig. 7 we can see our experimental setup. The exposed water was used for watering of wheat grains placed in two cups (200 grains for each cup). As a control group, watering by ordinary water, a third cup filled with the same amount of the wheat grains was used. New water samples for watering were being prepared in the same way once a day during the experiment. The obtained results are presented in Fig. 8, 9. We can see that the water exposed to the MP radiation has radically increased its biological activity (compare with the control group). The number of shoots has increased from 68 to 115 and their development was better. But the most surprising results have been obtained when the water samples were surrounded by the four-layered polyethylene film. The modified water influenced the number of the shoots and their growth negatively. The experiments were repeated, with slight variations several times and always led to practically the same results, but the level of growth suppression of the sprouts and its number were different. Fig. 10 shows photos, obtained during the similar experiment which was conducted from August 04th to August 12th, 2011. It can be seen that the germination of the sprouts is in accordance with the above-described experiment. The experimental results obtained at a frequency of 914, 2 MHz (121 channel) are shown in (Shalatonin & Mishchenko, 2010b). It should be noted that the shielded and exposed water was absorbed by the seeds much worse in comparison with other groups of the seeds. Therefore, this phenomenon could be considered as a visible reason of the sprouts bad development. Thus, it has been established that the EM radiation from the MP induced stable changes in the biophysical properties of the exposed water. It makes the water more active and changes dramatically the grains biological properties. The obtained results raise a

lot of questions. For example, how the biological activity of the activated water depends on parameters of the MP radiation (frequency value, level of power, duration of the exposition, parameters of the film and so on) and what physical properties of the water were changed due to exposure to this radiation.



Fig. 7. The process of exposing two water samples to the MP radiation. One of the glasses is wrapped by thin ($40\mu\text{m}$) four-layered PF. The exposure duration is 1.5 hour.

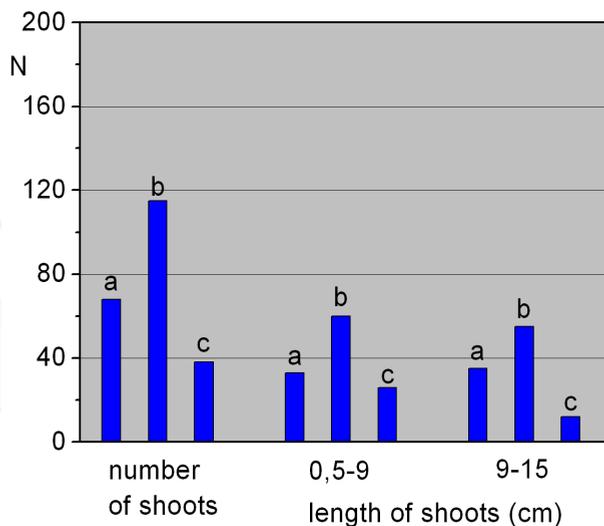


Fig. 8. Number and length of the sprouts for two groups of wheat grains. The MP operated at a carrier frequency of 902, 4 MHz (62nd uplink channel of GSM-900). The experiment was conducted from March 23rd to March 31st, 2010.

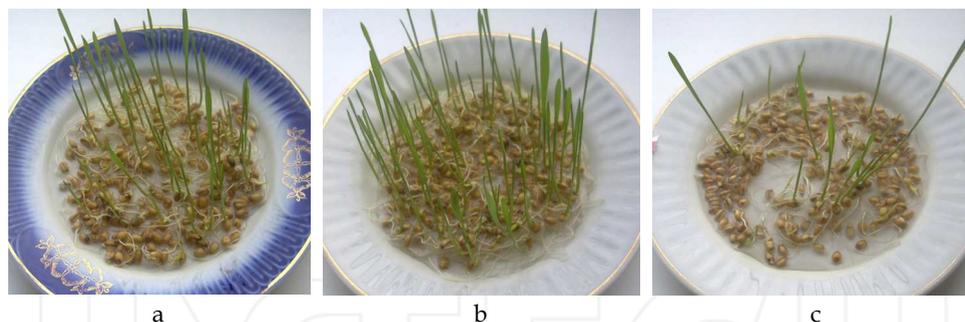


Fig. 9. Photos of the sprouts: a – watering with ordinary water; b – watering with exposed water; c – watering with shielded and exposed water. The shielded glass was wrapped by thin ($40\mu\text{m}$) four-layered PF. The exposure duration is 1.5 hour. It is the 8th day of the experiment. The experiment was conducted from March 23rd to March 31st, 2010

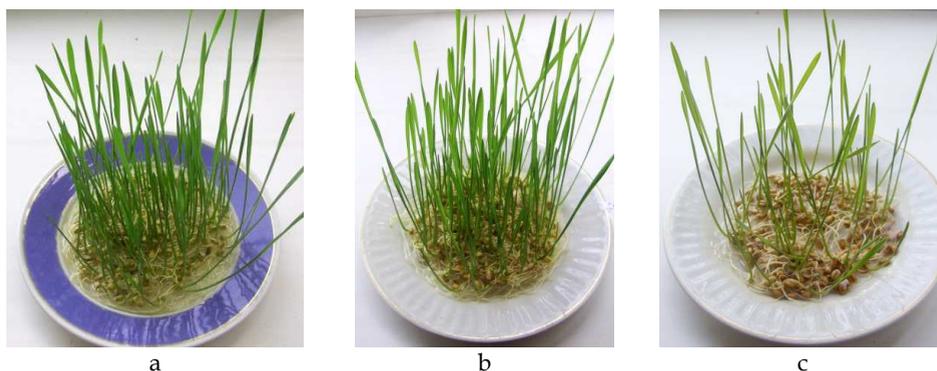


Fig. 10. Photos of the sprouts: a – watering with ordinary water (120 sprouts); b – watering with exposed water (131 sprouts); c – watering with shielded and exposed water (56 sprouts). The shielded glass was wrapped by thin ($150\mu\text{m}$) eight-layered PF. The exposure duration is 1.0 hour. It is the 8th day of the experiment. The experiment was conducted from August 04th to August 12th, 2011

3.2 Biological properties of the water exposed to the GSM-1800 MP radiation

Let us now describe some results of our experiments when using the same MP, which operated in the GSM-1800 band. We used practically the same procedures and in Fig. 11 the obtained results are given. It should be has in mind that the power density of the MP EM radiation is approximately 30 times less than the same value measured when using the GSM-900 operation of the MP. The diagrams in Fig. 11 show that there is a difference between the control cup and the cups watered by the exposed water. This indicates, in line with our results for the GSM-900 standard that the EM radiation exposure induces stable changes in physical state of the exposed water. It makes the water more active and changes the grains biological properties. The analysis of the quantity of the sprouted grains and the level of their germination showed the significant differences for sprouts in the different

cups. The level of germination and quantity of the shoots usually were better in grains, that were watered with the exposed water preliminary wrapped in the PF in comparison with the only exposed water. The same but more evident differences were observed earlier when using a carrier frequency of 1779.6 MHz (859 channel) (Shalatonin, 2011a). But the most important that the results obtained when using the GSM-1800 radiation showed the opposite relationships in comparison with the similar experiments when using the GSM-900 mobile phone radiation. This conclusion is in accordance with the measurement of pH. The pH level of the water exposed to the GSM-1800 MP radiation is usually getting larger than this value of the water exposed to the GSM-900 MP radiation. The typical changes of the pH of the exposed water samples (GSM-900 and GSM-1800) and of the ordinary water are shown in Fig. 12. It needs also to take into account that in this experiment the water samples

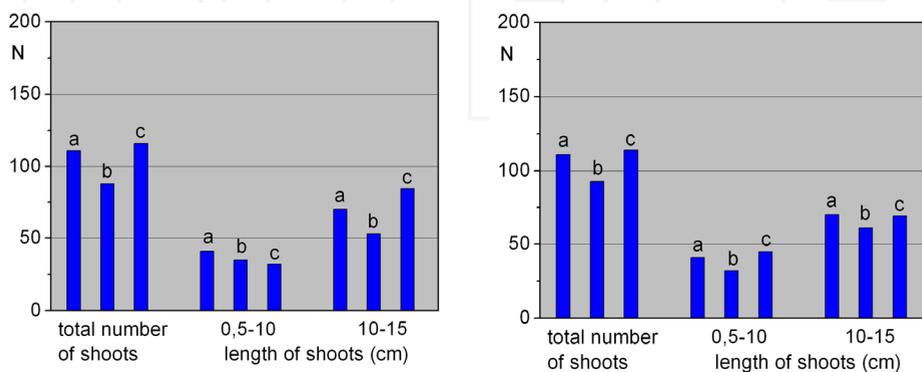


Fig. 11. Number and length of the shoots for different groups of wheat grains (on the left – $f = 1784.0$ MHz, channel 881; on the right – $f = 1784.8$ MHz, channel 883): a – watered with ordinary water; b – watered with exposed water; c – watered with shielded and exposed water. The shielded glass was wrapped by thin ($40\mu\text{m}$) four-layered PF. The exposure duration was 1.0 hour. The experiment was conducted from September 12th to September 20th, 2011

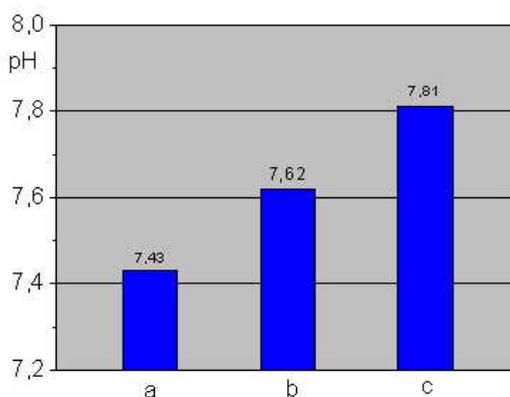


Fig. 12. Results of the measurement of the water pH: a – ordinary unexposed water; b – water exposed to the GSM MP radiation at $f = 902.4$ MHz; c – water exposed to the GSM MP radiation at $f = 1779.6$ MHz. The exposure duration is 1.0 hour.

received essentially different doses of the EM radiation. The matter is that as was noted above the power density of the applied dual-band phone when operating in the GSM-1800 standard was lesser than in the GSM-900 standard. Therefore, it can be supposed that the influence of the GSM 1800 phone radiation on the water is larger and this still remains unexplained. The experiment was carried out on August 2nd, 2011. The volume of every water sample was 450 mL.

3.3 A possible approach to explain the obtained results

Let us now consider the specific properties of the PF, and a possible biophysical mechanism, which are responsible for the obtained results. First of all it should be noted that polyethylene, like water, has a very high hydrogen concentration. It has been counted that a cubic meter of water contains 2.7×10^{29} protons (Ellis, 2011). In 1934 Enrico Fermi with colleagues were the first scientists who used hydrogenous materials including water to enhance the neutron induced radioactivity (De Gregorio, 2006). It turned out that water can be used as a suitable material in the path of the neutrons in order to slow fast neutrons down to thermal energies. Hydrogen rich substances are quite efficient at doing this as neutrons will lose more energy per collision with light atoms than with more massive substances. For other types of radiation, e.g. alpha particles, beta particles, or gamma rays, material of a high atomic number and with high density make for good shielding; frequently lead is used. However, this approach will not work with neutrons. The neutron's lack of total electric charge makes it difficult to steer or accelerate them. Charged particles can be accelerated or decelerated by electric or magnetic fields. These methods have little effect on neutrons beyond a small effect of an inhomogeneous magnetic field because of the neutron's magnetic moment. The main energy-loss mechanism occurs when they strike nuclei. It is often noted in the literature that the particles interact like billiard balls, the most efficient slowing-down occurs when the bodies that are struck in an elastic collision have the same mass as the moving bodies; hence the most efficient neutron moderator is hydrogen and some other light elements.

Since humans are mostly water, if they are standing in the way of a beam of neutrons, they will have a strong moderating effect. The slowing of the neutrons will cause damage and will induce other nuclear reactions. For example, if a thermal neutron is captured by hydrogen, a gamma ray will be released. Some substances inside of a human body will become radioactive as a result of exposure, causing the release of radiation even after the source of neutrons has been removed.

It is supposed that the energy-loss mechanism like above described could occur during a propagation of the AIR across the PF. According to (Veinik, 1991; Detela, 2001) and other authors the AIR consists of the charged particles having extremely small diameter ($\sim 1.6 \times 10^{-32}$ m) and mass ($\sim 1.2 \times 10^{-3} \times m_e$, where m_e – is the mass of an electron). It is not surprising that the AIR, modified by the PF can change its physical and, in turn, biological properties. But it should take into account that according to the abovementioned "theory" of the billiard balls, it needs to have inside of the PF some particles similar in size to that of the AIR.

A new model of the proton and neutron, that was recently experimentally discovered and our recent experimental results (Shalatonin, 2009) give a possibility to develop and justify an

appropriate approach to solving the problem. It was recently shown (Miller, 2008; Islam, 2010) that a neutron has a negative charge both in its inner core and its outer edge, with a positive charge sandwiched in between to make the particle electrically neutral (Fig. 13). It means in other words that the neutrons have a three-layered charge structure. The number within the every layer is the non-integer value of the layer charge (in units of $|e|$). Until recently physicists have long known that neutrons are made up of three quarks (subatomic particles) of two different types - one "up" quark with an electric charge of $+2/3$ and two "down" quarks, each with a charge of $-1/3$. It is plausible that the protons could also have the similar three-layer structure that is shown in Fig. 14. The discovery changes scientific understanding of how neutrons interact with negatively charged electrons and positively charged protons. We wanted to add that in our opinion this discovery keeps us thinking if we need a notion on such particles as quarks. Ellis (2011) writes that "scattering experiments with nucleons cannot liberate free quarks. ...No evidence for internal structure within quarks, or electrons, has yet been found. If quarks and leptons are discovered someday to be composite objects, bound states of some not-yet-known more fundamental constituents, then the length scale on which this binding occurs must be at least three orders of magnitude smaller than the femtometer scale of nucleons ($1 \text{ fm} = 10^{-15} \text{ m}$)". We suppose that protons and neutrons consist of electrically charged particles having the same nature as the airons. It is a very important peculiarity, because only in such a case nucleons can form lots of different wave patterns. That, in turn, may give rise to the origin of the effect of the water memory.

New findings may help understanding of how the AIR, inherent in the EMR, interacts with the protons of the PF. A physical parameter of the exposed water, which is closely related to the long-term changes in water was recently measured (Shalatonin, 2009). It was experimentally shown that multilayer standing-wave magnetic patterns (SWMP) appear around water samples exposed to the EM radiation. Fig. 15 shows a section of the magnetic three-layer structure (1, 2, and 3) obtained by using a one frequency EM radiation of 386, 4 MHz, which is very close, in our opinion, to a resonance excitation of the water protons. The quantity of the layers when using this frequency does not depend on the intensity of the EM radiation and the volume of this structure is unusually extensive. The last peculiarity as is well seen by comparing this pattern with the pattern shown in Fig. 16, is related in our opinion to the absorption resonance of the water sample protons. The SWMP remains fairly stable during a day but during several days their field energy is gradually dissipated. The patterns obtained for non-resonant frequencies had the same basic outlines but the number of the closed curves and its dimensions depended strongly on the EM radiation parameters. It is reasonable to suppose that the three-layer wave patterns of the nuclei in its resonant state may readily manifest themselves into space around the water samples. They reflect the internal charge structure of the nucleus described above. In other words, water has the macroscopic quantum properties that could give rise to the long-term physical effects. It is obvious that these magnetic structures are the result of the collective and coherent dynamics involving many nuclei. The only particular frequencies of the external EM sinusoidal radiation related to the resonant states of the hydrogen and the oxygen nuclei could lead to the resonant states of water. It should be noted that in according with the above described approach a real resonant frequency of the proton or neutron is the frequency of the AIR, which is transmitted together with the EM radiation. Its value is very high and at present there is no technical possibility to measure it. It was still nothing said of the particles in the PF, which, as was supposed earlier (the "theory" of billiard balls) should provide the energy-

loss mechanism of the AIR during its passing through the PF. We assume that every proton or neutron has external field patterns that could consist of the particles similar to that in the AIR. Therefore, it could be plausible to assume that the macroscopic SWMPs surrounding water samples are the AIR formed (at least partly) from the summarized individual AIR of the nuclei.

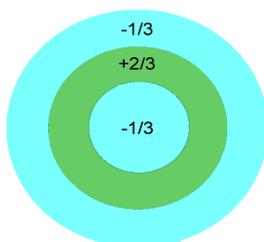


Fig. 13. A new model of neutron with charge layers. It has a negative fractional charge both in its inner core and its outer edge, with a positive fractional charge sandwiched in between to make the particle electrically neutral

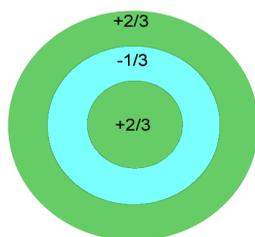


Fig. 14. A new model of proton with charge layers. It has a positive fractional charge both in its inner core and its outer edge, with a negative fractional charge sandwiched in between to make the particle electrically positive

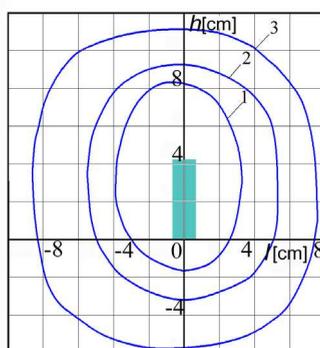


Fig. 15. Section of the three-layer standing wave magnetic pattern of the water sample following the exposure to the sinusoidal resonant EM radiation ($f_e \approx 386.4$ MHz). It is a resonance excitation frequency of water protons

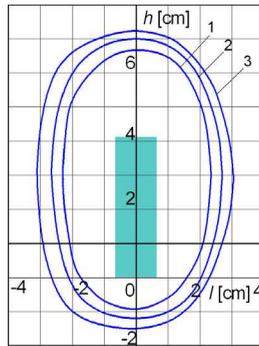


Fig. 16. Section of the three-layer standing wave magnetic pattern of the water sample following the exposure to the sinusoidal resonant EM radiation ($f_a \approx 381.5$ MHz). It is a resonance absorption frequency of water protons

Thus, our interpretation of the transition of the electromagnetically exposed water from the ordinary state to the long-range magnetically ordered state is mainly related to the inherent properties of the hydrogen protons and very probably the protons and neutrons of oxygen in molecules of water. New physical state of the water changes its biological properties. The exposed water can activate (mainly the GSM-900 MP radiation) or suppress (mainly the GSM-1800 MP radiation) the development of the cereals and possibly other bio-objects. The above interpretation is perhaps not so surprising. It is long known that almost all of an atom's matter is located in the nucleus. Atomic nuclei are thus unimaginably dense compared to chemical elements or chemical compounds. The density of a nucleus is more than 14 orders of magnitude greater than that of water. Therefore, without doubt a nuclear matter can play key role in the processes under consideration.

There is at least one more experimentally proven pattern of the manifestation of the behavior of atomic nuclei into the phase behavior of bulk liquid water (GSI Helmholtzzentrum für Schwerionenforschung GmbH, see References). The forces between individual components of the nucleus - the nucleons - vary according to distance in a manner remarkably similar to those between molecules in a liquid. At very short distances, the binding forces repel; at medium nucleon distances, they attract. In fact, in many ways, atomic nuclei behave very much like drops of liquid. Water, like all of the other matter surrounding us, is solid, liquid, or gaseous depending on its temperature and pressure. In the same way, nuclear matter - the charged protons and electrically neutral neutrons forming the nucleus of an atom - can assume various states. It turned out that even at a relatively slight increase in energy the nuclear matter undergoes a phase transition from the normal, liquid-like state to a nucleon gas. The experiments established that a caloric curve of nuclear matter (temperature-energy diagram) exhibits behavior analogous to the temperature curve of boiling water. This phenomenon was experimentally proved by the world's leading research laboratories.

In according with our notion not only water but theoretically all matter including solid materials, even stones, under certain conditions can manifest itself in a variety of effects associated with memory. For example, various methods of activation of various substances

are applied in homeopathy. Jerman et al. (2004) shown that biologically effective information from two chosen substances (herbicide glyphosate and pharmaceutical substance diazepam) can be non-chemically imprinted into a polyacryl based compound material to be polymerized by a high voltage electric field. Under suitable conditions the stored information can be reproduced, evoking specific effects, biological or physical, without any chemical contact with the original substance. The positive results were obtained by electrophotography and by volunteers.

Our recent experiments proved that the above discussed magnetic patterns can arise not only around pure water but also around solid hygroscopic materials having different water content. It turned out that the water which is dissolved in a wood sample keeps nevertheless its property to perceive and accumulate the non-thermal EM (AI) radiation (Fig. 17 and 18).

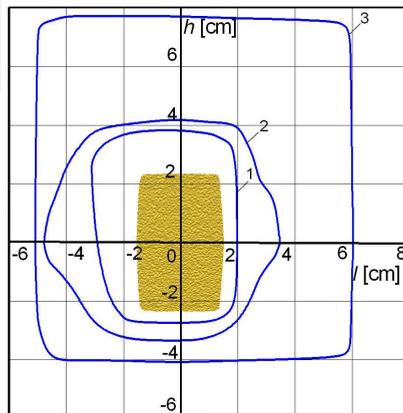


Fig. 17. Section of the SWMP of the first piece of wood following the exposure to the sinusoidal resonant EM radiation ($f_e \approx 386.4$ MHz). The exposure duration is 0.5 hour. The water content is 52%

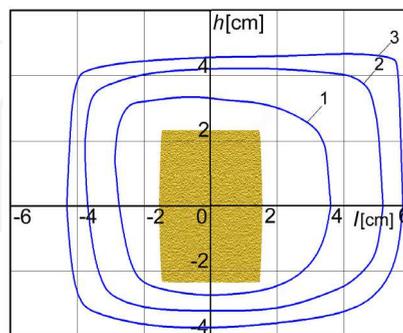


Fig. 18. Section of the SWMP of the second piece of wood following the exposure to the sinusoidal resonant EM radiation ($f_e \approx 386.4$ MHz). The exposure duration is 0.5 hour. The water content is 18%

The experiment was as follows. Two dried up equal conifer's pieces were saturated with water until the required moisture content and then exposed to the sinusoidal EM radiation at the resonant frequency of 386, 4 MHz. The prepared pieces of the wood were used for measuring the SWMPs. The obtained SWMPs are mainly similar but their volumes are different. It is seen that the larger water content leads to the bigger magnetic patterns.

3.4 Electromagnetic radiation, water and memory of living beings

As was noted at the beginning of this article, water is the main constituent of all living organisms. Many its properties are related to the storing and transferring of the vital information. And so a working hypothesis is that memory might be in particular susceptible to the extent of hydration. It is proved by recent experiments. Benton & Burgess (2009) investigated the cognitive functioning of 40 children (mean of 8 years and 7 months) twice, once after drinking 300 mL of water and on another day when no water was provided. Memory was assessed by the recall of 15 previously presented objects. Recall was significantly better on the occasions when water had been consumed. The ability to sustain attention was not significantly influenced by whether water had been drunk. Bar-David et al. (2005) found that memory but not four other measures of cognition was disrupted by dehydration. In according with our notions a basic phenomenon of the storing and transferring of the information in water is the interaction of the AIR (or the aeronic field), inherent in the informative EM radiation, with the protons and neutrons of the water (exactly speaking with the aeronic field of the nucleons). Therefore, it can be supposed that living beings exposed to the EM radiation could change their memory condition. Based on our experiments with wheat sprouts it can be assumed that the non-thermal EM radiation from the GSM-900 MP hardly may make memory worse and at the same time it is highly probable that the memory may get worse after exposing to the GSM-1800 MP radiation. Some studies using exposed rats at the GSM-900 radiation confirm our assumption (Dubreuil, 2003; Sienkiewicz, 2000 and others). There were no effects seen at a low SAR level but only some effects were found on exploratory activity at a high SAR level (3.5 W/kg). The recent study (Ntzouni et al., 2011) was conducted in order to investigate whether short-term memory is affected by ordinary GSM-1800 MP exposure. The authors concluded that an acute exposure did not affect mice memory but the chronic exposure had an impact on the recognition memory in a statistically significant manner. On the contrary, recently the first evidence has been reported that exposure directly associated with cell phone use (GSM 900 MP, SAR value, 0.25 W/kg) provides cognitive benefits i.e. improvement in transgenic Alzheimer's mice performance after long term (8 months) EMF exposure (Arendash et al., 2010). Wiholm et al. (2009) studied spatial behavior and learning (a virtual Morris water-maze) in subjects with (N=23) and without (N=19) symptoms related to mobile phone use. The design was both double-blind and crossover, and the exposure (884 MHz, SAR value, 1.4 W/kg) lasted for 2.5 hours. Spatial performance was measured before and after the exposure and the order of sessions was counterbalanced. The authors claim that the symptomatic group improved their performance during RF exposure. The authors themselves state that there is a need for replication. Luria et al. (2009) studied GSM (915 MHz, modulation 217 Hz, 0.25 W mean) effects in crossover, single blinded design on 48 subjects performing spatial working memory task, but found no effects after correction for multiple comparisons.

4. Conclusion

The experimental results presented here and previous studies show that non-thermal influences of various kinds, including EM radiation can considerably change the biophysical properties of water. We have demonstrated that wheaten grains can alter significantly their germination and development when watering with water, preliminarily exposed to the non-thermal mobile phone radiation. The biological response depends on parameters of the EM radiation especially on its carrier frequency and exposure duration. The main quality of the biological information (stimulating or depressive) preserved in water is mostly predetermined by choice of the GSM standard (GSM-900 or GSM-1800 mobile phone radiation). Based on conventional theory it is very difficult to interpret satisfactorily the revealed in this study and some other properties of water. Our results related to the polyethylene film were explained on the base of the well-known interaction of the polyethylene with fast neutrons. We suppose that the physical mechanism of the appearance of stable physical changes in the exposed water is conditioned by the presence of the biologically active field component that is inherent in the ordinary EM radiation. In order to simplify referring to this kind of radiation it is convenient to call it as the active informational radiation (AIR) and then some particles, which correspond to this radiation, could be called as airons. Polyethylene film due to a high concentration of hydrogen (H atoms) scatters and slows airons. It is supposed that the polyethylene action is similar to its action to the fast neutrons passage. Therefore, the polyethylene and other hydrogenous polymers could be used to study the physical properties and parameters of the AIR. As it turned out, the changes in the physical properties of the AIR lead to significant changes in biological properties of the exposed water. In further work it would be important for checking our assumptions to use a pure hydrogen gas instead of the polyethylene. The hydrogen is one of the main compounds of water and of all organic matter. Since humans are mostly water, it is plausible to assume that the body fluids could be the primary receptor of the aironic field. And so, it is not surprising that biophysical properties of the exposed water were being changed when placing the polyethylene film between a water sample and a source of the EM radiation (mobile phone). The next assumption is that the mechanism underlying the changes in the biophysical properties of the exposed water is related to the nuclear properties of matter and water in particular. The multi-layer standing-wave magnetic patterns, which appear around the water samples, preliminarily exposed to the EM radiation most likely go hand in hand with the recently discovered complex three-layered charge structure of protons and neutrons. It is supposed that these patterns are the result of the manifestation of the collective and coherent microscopic phenomena involving many nuclei in molecules of the exposed water. In other words, exposed water has macroscopic magnetic properties that correspond to the microscopic properties of the charge structures of its nuclei. The EM radiation (the AIR) interacts with water at a nuclear level: airon-driven nuclear reactions lead to the long-term changes of specific charge configurations of nuclei that, in turn, affect the biological properties of water. The investigation of the resonant properties of the protons and neutrons related to the AIR are important for possible technological and biomedical applications (Shalatonin, 2011a). Especially it is related to the hydrogen which possesses certain beneficial characteristics and widely used as a source of energy. The obtained results could provide a practical approach to the problem of the harmful EM radiation shielding. Finally, it should be noted that these results should be treated with some caution until other studies will confirm them.

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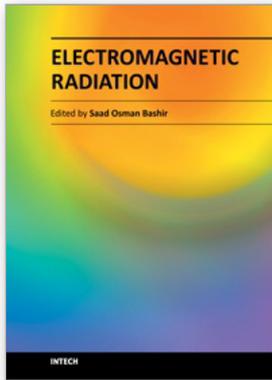
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The application of electromagnetic radiation in modern life is one of the most developing technologies. In this timely book, the authors comprehensively treat two integrated aspects of electromagnetic radiation, theory and application. It covers a wide scope of practical topics, including medical treatment, telecommunication systems, and radiation effects. The book sections have clear presentation, some state of the art examples, which makes this book an indispensable reference book for electromagnetic radiation applications.

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