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The Role of Modification of the Structure of Water and Water-Containing Systems in Changing Their Biological, Therapeutic, and Other Properties Overview

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Abstract: Based on published research on modifying the structure of water and water-containing systems, we assess external influence methods: temperature, magnetic field, light radiation, and their combination. We evaluate changes in the electrophysical, photo- and pH-metric biological, therapeutic, and other properties of water systems using non-destructive electrophysical research methods, i.e., thermometry, pH, laser interference, dynamic light scattering, microelectrophoresis, conductivity, surface tension, dielectric constant, polarimetric measurements, atomic force microscopy, and UV and EPR spectroscopy. The effects of temperature or magnetic field lead to a change in the content and size of water clusters, and physicochemical, biological, therapeutic, and other changes in the properties of water and water-containing systems. The combined effect of a magnetic field and curative mud and the impact of magnetised mineral water have a more pronounced therapeutic effect than only mineral water or curative mud. The data presented indirectly indicate structural changes in water and water-containing systems. We conclude that the primary mechanism of action of a magnetic field, light, or a combination of these factors on water and water-containing systems, including mineral water and therapeutic mud, is a change in the structure of water.

Keywords: light; magnetic field; temperature; water structure; mineral water; therapeutic mud

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1. Introduction

One of the most critical factors affecting a population's health is sufficient quantity and quality of drinking water. Thus, the freshwater problem has firmly entered the international political agenda in the last decade of the twentieth century. The large number of people suffering from varying degrees of water scarcity (today, about 1.1 billion) has forced the world community to recognise the expansion of access to drinking water as one of four key components [1]. The profession knows that along with hydrological studies, studies of available sources of drinking water, determination of their quantitative parameters, and the search for new sources of drinking water, it is necessary to assess its quality constantly. According to the established global practice, water suitability for drinking is assessed according to four criteria: epidemiological, organoleptic, sanitary-toxicological and radiation [2]. However, more and more data have been accumulating in recent years, indicating another criterion not yet considered: the structuredness of drinking and mineral water. Experimental and clinical studies have shown that the degree of structuredness of water largely determines its biological activity, and the structured phase of water plays a vital role in the life of organisms [2–10].

The question of changing the properties of water due to its structural rearrangement began to be widely studied about 30 years ago in research on the treatment of water with a magnetic field. In some research, other types of impact have the same direction in changes in the properties of water, which made it possible to call it activated [7,9,11]. At present, in science and society, there is an increased interest in studying changes in the biological, therapeutic and other properties of water and water-containing systems after purposeful modification of its structure using, in particular, low-energy effects [8,12–15]. According to several authors, the study of primary and secondary mechanisms of action on water and water-containing systems of low-energy therapeutic physical factors, including the molecular level, is of practical importance [15–19]. In this case, a special place is occupied by changes in the structure and properties of water, primarily intracellular water [15–22]. According to [18], water is a crucial molecule in the action of therapeutic physical factors.

Water in biological tissues is "bound" with biomolecules and is in a "free" state. The orientation of bound water on the surface of protein molecules leads to forming a water shell structured like ice. In organisms, structured water plays the role of a structural and energy framework of protein bodies. This, in combination with organic compounds, creates templates, which include RNA and DNA. The double helix is determined by the parameters of the metastable structure water [23]. The structure of bound water affects the properties and functions of protein macromolecules, enzyme activity, structure and biological membranes [8].

The biochemical and physiological processes of adaptation also develop through the interaction of molecules with water. It was found that with prolonged or repeated exposure to external factors, the body adapts, accompanied by an increase in the content of bound water in the blood. If the impact exceeds the adaptive capabilities of the organism, then maladjustment occurs, which is accompanied by a decrease in the content of bound water. At the same time, adaptogens increase the content of bound water in the blood of experimental animals [8].

The purpose of this review is to show possibilities of a multidisciplinary approach to assessing the role of modification of the structure of water and water-containing systems in changing their biological, therapeutic, and other properties.

2. Liquid Water Structure

The modern view of the structure of water is that the water, by molecules connected by hydrogen bonds [8,14,24], forms a complex structural organisation, and the structure of an aqueous solution determine by interactions carried out in solution between atoms, ions and molecules [24–27]. In this case, in water and its solutions, there is a continuous formation and destruction of associates of water molecule clusters [8,25,28–30]. The minimum size water cluster consists of six molecules [31]. Using methods of dynamic light scattering, microelectrophoresis, conductivity, surface tension, dielectric constant, polarimetric measurements, atomic force microscopy, UV and EPR spectroscopy, it was shown that in the presence of a magnetic field, water clusters of up to 400 nm in size are formed in highly dilute solution [17,32].

Goncharuk et al. found giant water clusters (GWC) with sizes up to 100 μm, whose lifetime ranges from 10–11 to 1 s and more, by using the laser interference method [33]. The presence of GWC does not contradict the previously obtained experimental data on the existence in the water of nanometre clusters with a relaxation time of 10^{-11}–10^{-12} s [14].

According to several authors, the sizes and properties of such giant structural formations in water-containing systems are similar to the dimensions and properties of the cells of organisms. GWC, like the cells of organisms, have a "membrane" and a transmembrane potential (about 100 mV). At the same time, in a large cluster of water, there can be smaller clusters of water [33], just as mitochondria and other organelles are in the cell. Clusters can interact and form structures similar to the structure of multicellular organisms [14]. The presence of the "cellular" structure of water allows one to explain the cellular structure of living organisms since this differentiation already "a priori" exists in the water. The organic components of the future cell in biosystems can only fill the already finished cell [34].

Many works have shown that the sizes of clusters and the properties of water depend on temperature, the concentration of solutions, distance from a solid surface, the effect of a magnetic field and other factors [13,24,33,35–38]. For example, when we treated water with a magnetic field, the content of primarily large clusters decreases in it [35].

Water molecules are in continuous thermal motion that is well known. In this case, when studying the structure of water and aqueous solutions, it is possible to talk about the specific position of individual molecules (dipoles) of water relative to each other in a time interval of less than 10^{-13} s. Furthermore, it is essential to note that the structure of water reproduces under stable thermodynamic conditions. Therefore, when using non-destructive research methods under various influences, it is possible to evaluate the structure of water, which should be understood as a change in the ratio and mobility of "free" water dipoles and water dipoles included in clusters, in the structure of hydrated ions and in other kinetic formations that exist for a short time or for a long time [36,39].

In recent years, based on new designs of capacitive measuring cells, a new, practical and easily realisable method has been developed for assessing the structure of water and water-containing systems based on measurements of ultra-low densities of sinusoidal reactive currents (from 10 nA/cm^2 to 100 nA/cm^2 per various frequencies from 100 Hz to tens of MHz) [39–41]. However, this method is only one of the known methods that allow one to assess the effect of the mobility of "free" (more mobile water dipoles) and "bound" water in various formations of water dipoles on the value of the reactive current in the objects under study. Furthermore, this method makes it possible to evaluate the structure of water in aqueous solutions and water-containing objects. In this case, measurements can be carried out in the resonant mode at different resonant frequencies [17,36,37,39,40] and include the measuring cell in the oscillatory circuit of the generator of sinusoidal oscillations [41].

Below are brief descriptions of methods for assessing the structural organisation of water and water-containing systems and experimental data to evaluate structural changes under various external influences.

2.1. Assessment of Changes in the Structure of Water and Water Systems Using Electrical Parameters

To assess the structural transformations of water and aqueous solutions changing their physicochemical properties, researchers have used a non-destructive method for determining the structure of water and water-containing systems and various measuring cells [17,23,37,39,41–44]. The electrical capacitance value uses as a parameter for assessing the structure of water or an aqueous solution.

Researchers carried out studies to determine the parameters of the optimal measuring cells for different tasks, to assess the effect of the distance to a solid surface and the material of a solid surface on the structure of liquids [43]. For this, measuring cells were used, making it possible to create different heights of the liquid layer between the capacitor plates and apply different reactive current frequencies (Figure 1A) [43,44].

The water layer with a thickness of approximately 300 μm, located near a solid surface (boundary layer water), differs in its properties from the rest of the water ("bulk" water) [12,13]. For example, in experiments with a 1.5×10^{-1} M sodium chloride solution (saline), the distance to the solid surface (glass) differed from 50,000 μm to 5 μm [43]. It turned out that with a decrease in the distance to the solid surface from 50,000 μm to 2500 μm, the values of electrical capacitance at frequencies from 1 kHz to 3000 kHz changed insignificantly. Only at a frequency of 10,000 kHz did the electrical capacitance decrease by 4% ($p < 0.01$); when the distance to the solid surface decreased from 50,000 microns to 5 microns, the decrease in electrical capacitance was more pronounced when the distance decreased from 75 microns to 25 microns. (Figure 2).

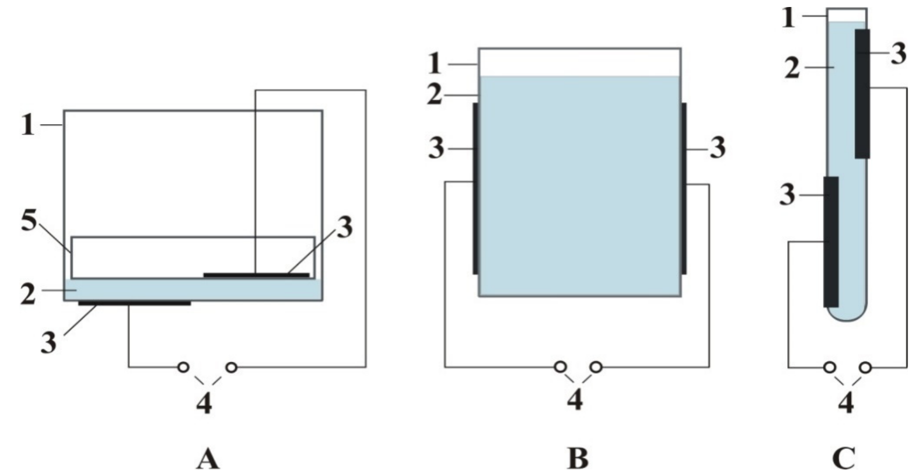

Figure 1. Scheme of measuring cells for assessing changes in the electrical parameters of water and water-containing systems. 1—Glass container for the test liquid, 2—test liquid, 3—capacitor plates made of non-magnetic material without direct contact with the test liquid, 4—terminals for connecting the signal from the generator of sinusoidal oscillations, 5—glass container with a flat bottom. (**A**) Measuring cell, allowing to create different heights of the liquid layer between the capacitor plates; (**B**) rectangular measuring cell with a distance between capacitor plates of 7 cm, (**C**) test tube with a diameter of 20 mm and a length of 200 mm in which the capacitor plates are displaced relative to each other in parallel planes and do not have a surface located opposite each other.

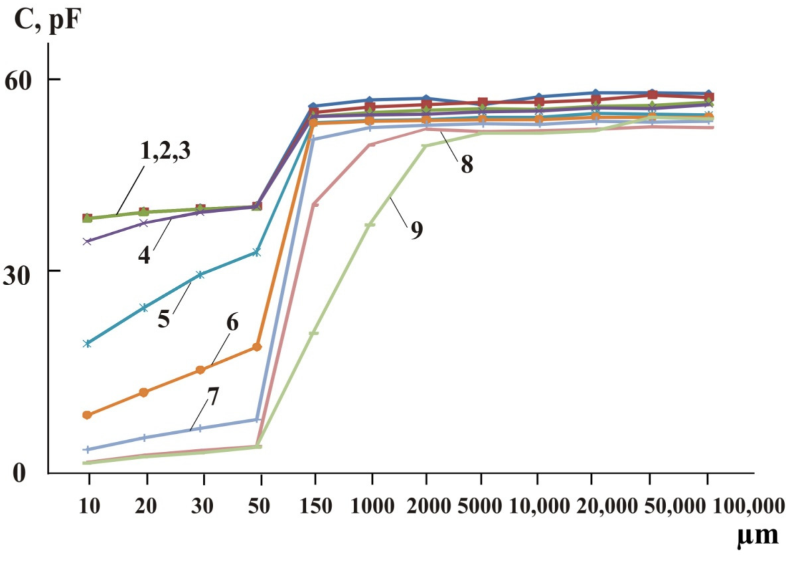

Figure 2. Dependence of the electrical capacitance (C, pF) of a sodium chloride solution with a concentration of 1.5×10^{-1} M on the distance between the capacitor plates (µm) at different frequencies of reactive current: 1—1 kHz, 2—3 kHz, 3—10 kHz, 4—30 kHz, 5—100 kHz, 6—300 kHz, 7—1000 kHz, 8—3000 kHz, 9—10,000 kHz.

In this case, the electrical capacitance of 1.5×10^{-1} M sodium chloride solution at frequencies of 1 kHz, 100 kHz, and 10,000 kHz decreased by 26%, 35%, and 74%, respectively ($p < 0.001$). Furthermore, the quality factor of the oscillatory circuit, when a measuring cell was included in it, at resonance frequencies of 30 kHz, 100 kHz, and 300 kHz, decreased in a more pronounced manner, by 77%, 86%, and 82%, respectively ($p < 0.001$).

The results obtained indicated the structural changes in the near-wall layer of the saline solution (at a distance to the solid surface of less than 5000 µm). There is a decrease in the mobility of water dipoles, which is more pronounced in the resonant measurement mode.

Figure 3A,B show the dependence of the electrical capacitance of distilled water and aqueous solutions of sodium chloride at different frequencies of reactive current, using a measuring cell with a distance between the capacitor plates of 7 cm and a test tube with a diameter of 20 mm and a length of 200 mm. In this test tube, the capacitor plates are displaced relative to each other in parallel planes and do not have a surface opposite [44]. It turned out that when using both measuring cells with an increase in the frequency of the reactive current from 1 kHz to 100 kHz, the electrical capacitance of distilled water decreases many times ($p < 0.001$) (Figure 3). The electrical capacitance practically does not decrease with a further increase in frequency from 100 kHz to 3000 kHz. These results agree with the previously obtained data. They are because, in distilled water, its molecules are sufficiently tightly bound to each other in associates, making it difficult to rotate the water dipoles with an increase in the frequency of the reactive current.

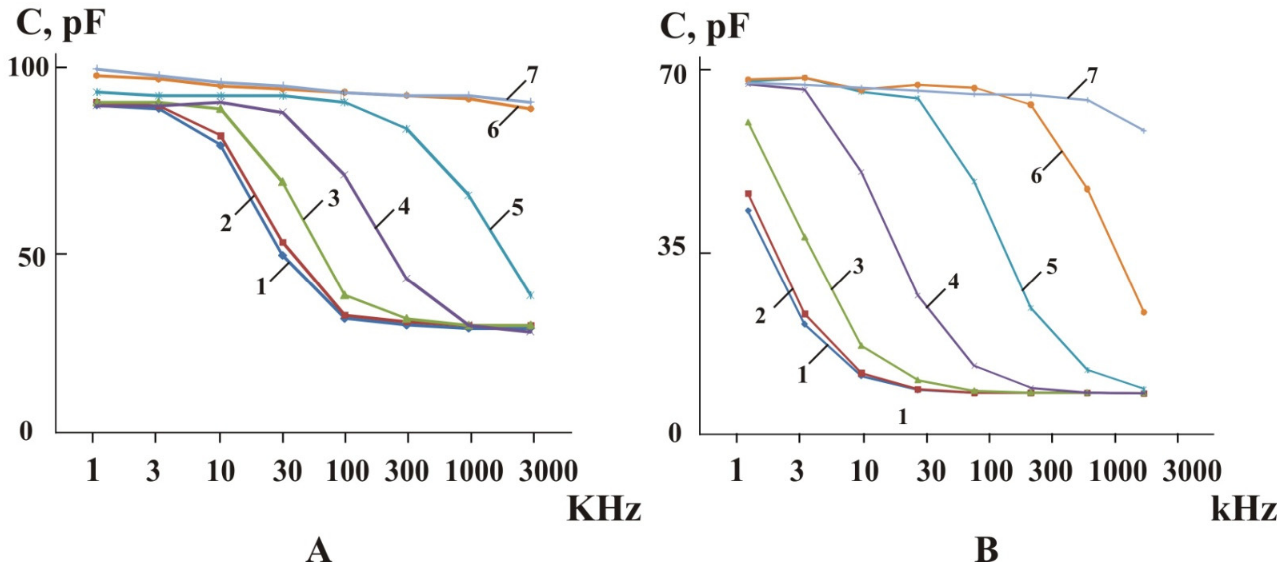

Figure 3. Dependence of the electrical capacitance of distilled water and aqueous solutions using different measuring cells to varying frequencies of reactive current and concentration of NaCl solution: 1-distilled water, 2, 3, 3, 4, 6, and 7—solutions of sodium chloride salt in concentrations of 1×10^{-6} M, 1×10^{-5} M, 1×10^{-4} M, 1×10^{-3} M, 1×10^{-2} M, and 1×10^{-1} M, respectively. (**A**): rectangular measuring cell with a distance between the capacitor plates of 7 cm; (**B**): test tube with a diameter of 20 mm and a length of 200 mm. In this test tube, the capacitor plates are displaced relative to each other in parallel planes and do not have a surface located opposite each other.

With an increase in the concentration of an aqueous solution of NaCl, a sequential increase in electrical capacitance occurs, first at low and then at higher frequencies. The increase is due to partial destruction of the cluster structure of water [24,35] with an increase in the concentration of sodium chloride solution, which manifested in an increase in the mobility of water dipoles, and, accordingly, in a rise in the electrical capacitance of sodium chloride solutions.

However, a less pronounced electrical capacitance decreased with increasing frequency with the greater distance between the capacitor plates (7 cm), both in experiments with distilled water and experiments with sodium chloride solutions at all concentrations used from 1×10^{-6} M to 1×10^{-1} M. Considering the above data [43], this is a consequence of changes in the structure of water and its solutions near a solid surface.

Thus, with an increase in the concentration of sodium chloride solution, the destruction of supramolecular formations (associates) of distilled water occurs [24,35], hydration formations form, which in this study manifested in an increase in the mobility of dipoles and, accordingly, to a rise in the electrical capacitance of solutions.

In the near-wall layer, another structure formed, which is accompanied by a decrease in the mobility of water dipoles. Based on the results obtained in the article [43], we conclude that more pronounced changes in electrical parameters are observed at a distance from the solid (glass in this study) surface of fewer than 10,000 microns for distilled water and less than 75 microns for aqueous solutions of sodium chloride. The decrease in the electrical capacitance of aqueous solutions in the near-wall layer nonlinearly depends on the distance to the solid surface, the concentration of solutions, the nature of the solute, and the surface material [43].

The data of experiments with distilled water and other solutions [43] recommend using measuring cells in which the capacitor plates are located at a distance of 5 cm to 10 cm from each friend (a diagram of one of these cells shown in Figure 1B) for studies with distilled water and water-containing systems. On the other hand, it is advisable to use other measuring cells to study the simultaneous influence of various factors on the structure of water, water-containing systems, and the near-wall layer, for example, in a test tube with a diameter of 20 mm and a length of 200 mm in which the capacitor plates are displaced relative to each other in parallel planes and do not have a surface located opposite each other [44]. A diagram of one of these measuring cells is in Figure 1C.

Further, it is advisable to evaluate the change in the structure of water with a change in temperature and the effect of various physiotherapeutic factors (temperature, magnetic field, light). As already shown above, the study of therapeutic physical factors' mechanisms of action and physiotherapy methods is of fundamental importance [18]. Among the primary and secondary mechanisms of action of therapeutic physical factors, a special place is occupied by changes in the structure and properties of water, especially intracellular water [15–22].

2.2. *Assessment of the Effect of Temperature on the Structure of Water and Water-Containing Systems*

The dependence of the structure and other parameters of water on temperature is shown in several works [35,44,45]. In these works it was shown that the minimum specific heat of water is at a temperature of 35–37 °C. According to [46], the heat capacity values do not change in the temperature range from 30 °C to 38 °C, probably indicating the absence of significant structural rearrangements in water in this temperature range.

Interestingly, in the temperature range 35–40 °C, a local maximum of the activation entropy is also observed [47], which indicates a local increase at these temperatures of the lability of processes and the degree of freedom of chemical and biochemical reactions. The results of studies with heating and cooling of liquids are in Figure 4 [44].

In these cases, distilled water was cooled in a test tube at room temperature or heated and cooled in a 100 mL container. In addition, distilled water and sodium chloride solutions at concentrations of 1×10^{-5} M, 3×10^{-5} M, 1×10^{-4} M, and 1×10^{-3} M also were cooled in a rectangular measuring cell with dimensions 70 mm × 70 mm × 110 mm.

The relative time of change in the temperature of liquids by 1 degree (Ti%) was calculated using the following formula:

$$T_i\% = \frac{\Delta t_i - \Delta t_{i-1}}{\Delta t_i} \times 100$$

where T_i (%) is the relative change in temperature (in%) at the *i*-th degree, Δt_i is the time during which the temperature changes by 1 degree at a temperature of ti degrees, Δt_{i-1} is the time during which the temperature changes by 1 degree at temperature t_{i-1} degrees.

It turned out that when using different measuring cells and different cooling techniques, all curves of the relative durations of temperature changes T_i *(%)* by 1 °C had maxima at 39 °C and 42 °C [44].

If the temperature of distilled water and salt solutions increases from 20 °C to 40 °C, the destruction of clusters with sizes from 2 to 40 µm occurs [35]. Since the process requires additional energy, we assume that the presence of local maxima on the curves of the relative time of decrease (or increase) in temperature is a consequence of a reduction in the rate of formation (or destruction) of clusters with the release (or absorption) of thermal energy, accompanied by a slowdown in the relative time of temperature change of water and aqueous solutions.

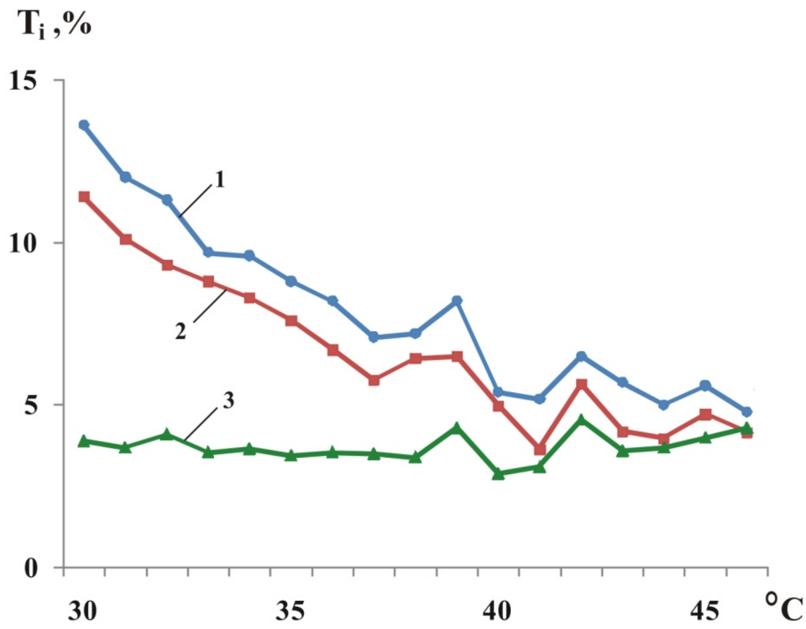

Figure 4. Dynamics of relative changes in temperature Ti (%) by 1 °C when cooling and heating liquids. 1–distilled water in a test tube (cooling in the air at room temperature); 2—the curve of the average values of the cooling curves of distilled water, sodium chloride solutions at concentrations of 1×10^{-5} M, 3×10^{-5} M, 1×10^{-4} M, 1×10^{-3} M. The liquids were in a measuring cell with a capacity of 500 mL and cooled down at room temperature in a flowing air from the fan, 3—the curve of the average values of the curves of cooling and heating of water in a vessel with a capacity of 100 mL. Explanations to Ti (%) in the text.

The presence of local maxima on the curves of the relative time of decrease (or increase) in the temperature of distilled water and sodium chloride solutions (at 39 °C and 42 °C) indicates a slowdown in temperature changes at these points, which is associated with structural rearrangements; in water, this is accompanied by the release (or absorption) of heat.

2.3. *Influence of the Magnetic Field on the Structure of Water and Water-Containing Systems*

The magnetic field directly affects the properties of water and is, in particular, a therapeutic physical factor, the influence of which on water is of great importance [18]. Many authors generally believe that the biological effect of magnetic fields is realised exclusively through the aquatic environment of the body [22]. In one study [41], when a measuring cell with a distance between the capacitor plates of 7 cm was connected to the oscillatory circuit of a sinusoidal oscillator, it turned out that after treatment with a magnetic field of distilled water, the initial oscillation frequency of 13.8 + 0.01 kHz decreased by 0.9% ($p < 0.01$), and the amplitudes of oscillations at frequencies of 13.8 + 0.01 kHz, 113.3 + 0.05 kHz and 279.0 + 0.13 kHz decreased in a more pronounced manner, by 3.1% ($p < 0.05$), 22.9% ($p < 0.01$), and 14.1% ($p < 0.01$) (Figure 5).

The LC oscillator frequency decreases with the increased capacitance of the capacitor in the oscillatory circuit. The decrease in the low oscillation frequency of the generator occurs due to the increase in the electrical capacity of magnetised watery. An increase in the electric capacity may reflect such changes in the structure of water, in which there is an increase in the number of water dipoles rotating in an electric field.

The oscillation amplitude of the generator decreases with increasing energy losses in the oscillatory circuit. Hence, the decrease in the amplitude of oscillations in magnetised water reflects the increase in energy losses due to the reduced mobility of water dipoles. The decrease in mobility of dipoles could occur due to a reduction in the size of the water clusters after magnetisation [35]. As a result, water dipoles are more connected with each other.

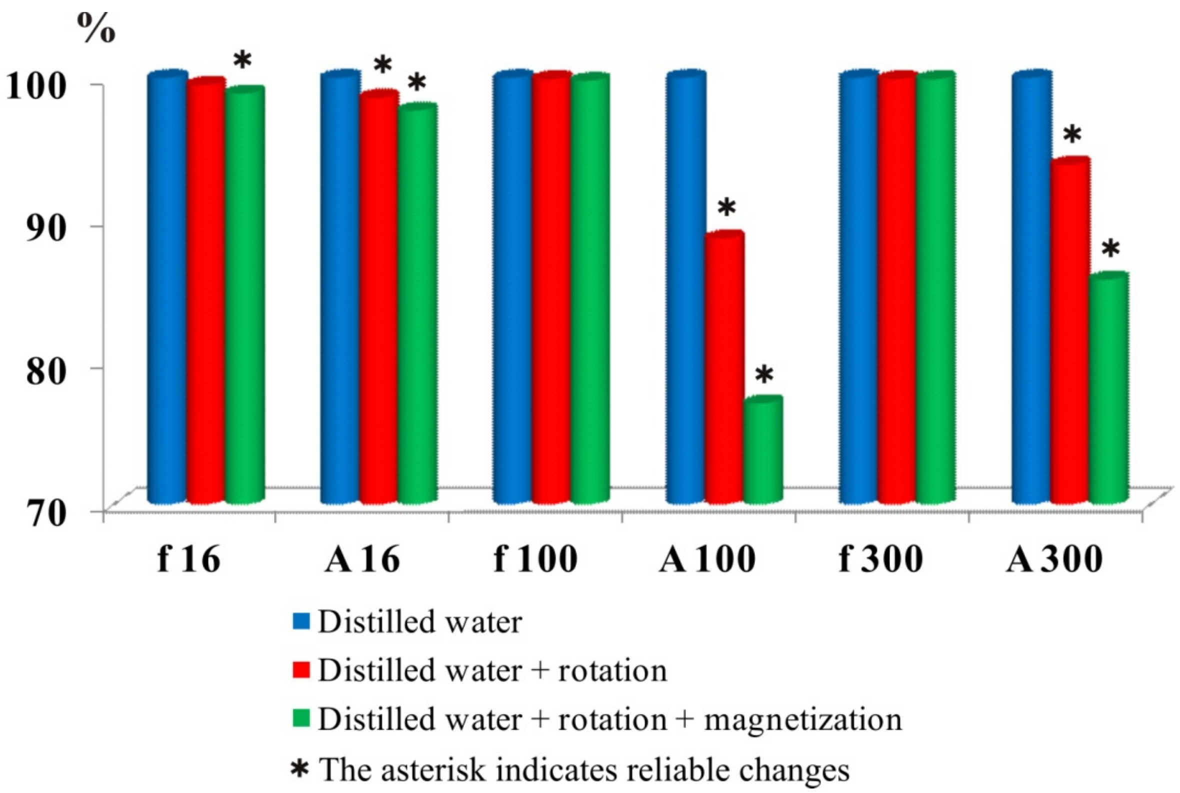

Figure 5. Influence of rotation of distilled water and its magnetisation by rotation on the frequency and amplitude (in per cent of the initial values) of sinusoidal oscillations of the generator (with the inclusion of the measuring cell in the oscillatory circuit). F1 and A1-frequency (initial value 13.80 ± 0.01 kHz) and vibration amplitude; F2 and A2-frequency (initial value 113.30 ± 0.05 kHz) and vibration amplitude; F3 and A3-frequency (initial value 279.00 ± 0.13 kHz) and vibration amplitude. The asterisk indicates reliable changes. (There are no problems copyright issue with this figure).

The decrease in the oscillation amplitude of the LC generator after the magnetisation of distilled water corresponds to the previously obtained results. It was shown in [42] that after treatment with a magnetic field of distilled water, the amplitude of sinusoidal oscillations at a frequency of 1–30 kHz decreases by 5–8% ($p < 0.001$). Results indicate a decrease in mobility water dipoles and, accordingly, an increase in structuredness of water, by the rise in pH value from 5.27 + 0.02 to 5.43 + 0.02 ($p < 0.001$) [11,48]. Several other studies noted a change in the pH and other properties of water under the influence of a magnetic field [49,50].

In addition, when studying the optical properties of distilled water after its magnetisation, it was found that the absorption of infrared and ultraviolet radiation, Raman scattering, and X-ray diffraction changes. The authors also associate these changes with the strengthening of the cluster structure of water [51].

2.4. Assessment of the Influence of the Magnetic Field on the Properties of Mineral Water and Therapeutic Mud

Currently, there are many studies in which the possibility of increasing the effectiveness of therapy under the combined effect of a magnetic field and natural therapeutic physical factors, mineral waters, and therapeutic muds are being studied [52]. Considering this, it is of practical interest to study the effect of a magnetic field on the properties of mineral water and therapeutic mud. For example, an increase in pH value was observed during magnetisation of Karachinskaya mineral water and magnetisation of distilled water [52]. Furthermore, the magnetisation of the Karachinskaya mineral water and distilled water increased the structuredness. Since the body is two-thirds water, the intake of the magnetised mineral water "Karachinskaya", which is more structured than the non-magnetised mineral water "Karachinskaya", is likely to have a more pronounced positive effect on animals and humans.

Indirectly, this assumption is evidenced by research data on the increase in bound water content in the blood when the body adapts to adverse effects. On the contrary, during maladjustment, the content of bound water decreases [8].

Interesting results were obtained when studying the effect of a magnetic field on the enzymatic activity of therapeutic mud [52]. It turned out that when it is magnetised, the catalase activity increases by 35%. Moreover, with the magnetisation of the aqueous fraction of therapeutic mud and only reagents for determining the enzyme activity, the increase in catalase activity was almost wholly reproduced. Considering these data, one of the mechanisms of the action of the magnetic field on therapeutic mud and magnetised mud on the body may be a change in the structure of water and, accordingly, the structure of the water fractions of these study objects. According to [53], the proportion of bound water in therapeutic mud is 25%. Furthermore, the data obtained on changes in catalase activity are consistent with the data of another study on the effect of the structure of bound water on the activity of enzymes [8].

2.4.1. Influence of Infrared and Light Radiation on the Properties of Water and Water-Containing Systems

The impact of infrared and light radiation on the properties of water and water-containing systems was studied in several works [20,21,38]. In [38], distilled water was exposed to laser radiation with a wavelength of 633 nm and a power of 5 mW for 30 s to 5 min. Then, the optical density was measured on a photoelectric colourimeter in the wavelength range from 314 nm to 980 nm. The most significant changes in optical density were observed at 315 nm and 980 nm. In this case, with a duration of exposure from 0.5 min to 2 min, the maximum decrease in the optical density of water occurred. Based on the results obtained, the author concludes that one of the possible components of the primary mechanism of laser action is a change in the structure and, accordingly, the properties of water in organisms. In [20], an increase in pH ($p < 0.01$) was observed with a single exposure of a He-Ne laser to tap water with a duration of 30 s. Distilled water was less susceptible to the He-Ne laser. The effect of infrared and red laser radiation on blood hydration, components, and polymers was also studied. Under the influence of this radiation, an increase in the amount of bound water was observed in all media [8].

2.4.2. Influence of the Combined Action of a Magnetic Field and Light Radiation on the Properties of Water

It is interesting to compare the above data on the influence of the magnetic field and light radiation on the properties of water with similar data combined. Increased pH was observed under magnetic field and He-Ne laser on water in [20] and the combined effect of these factors caused a more significant increase in pH than each factor taken separately. Distilled water was less susceptible to the action of the magnetic field and the He-Ne laser [20]. Similar results were obtained in [21]. It was concluded that the combination of a constant magnetic field and laser radiation upon activation of tap water gives a synergistic effect, which manifests in a more significant change in pH than each factor's action separately.

Thus, in the above studies, it was shown that the effect of a magnetic field and light radiation causes changes in the structure of water and water-containing systems. In this case, the combined effect of a constant magnetic field and laser radiation on the properties of water has a synergistic effect.

2.5. Assessment of the Therapeutic Effect of the Magnetic Field Combined with Mineral Water or Therapeutic Mud

Experiments on animals have confirmed the above assumption about a possible increase in the therapeutic activity of the mineral water "Karachinskaya" treated with a magnetic field. The magnetisation of this mineral water significantly increases its hepatoprotective effect in toxic hepatitis. In addition, it expands the spectrum of its therapeutic action in treating chronic non-calculous cholecystitis with various concomitant diseases and, in general, increases the effectiveness of treatment [52,54]. Furthermore, the magnetised mineral water "Karachinskaya", along with a normalising effect on the motor function of the gallbladder and immune status, is more pronounced than non-magnetised mineral water, reduced the inflammatory process in the gallbladder and reduced the initially increased acidity of gastric juice. Based on the data obtained, methodological recommendations were given to use the magnetised mineral water "Karachinskaya" for health improvement and disease prevention [52,54].

The results obtained in experimental and clinical studies indicate an increase in the structuredness of mineral water due to magnetisation and increases in its therapeutic effect. Furthermore, the assumption's validity is partially confirmed because adaptogens also increase the content of bound water in the blood of experimental animals [8].

Positive results were also obtained in a study with the combined effects of a magnetic field and therapeutic mud (sapropel). In an experiment with toxic hepatitis in rats, the course combined exposure to sapropel and an inhomogeneous constant magnetic field, which, compared with the effect of therapeutic mud applications, accelerated the recovery processes while reducing the degree of tension of the body's regulatory processes [52,55,56].

These experimental results was as the basis for developing a new method of treating osteoarthritis complicated by reactive synovitis utilising a course of combined therapeutic mud and a magnetic field. When designing this treatment method, the above research results on changes in the structure of water and water-containing systems during their heating and cooling were taken into account [44]. This study showed that the curves of relative temperature changes have local increases (maxima) at 39 °C and 42 °C, indicating significant changes in the structure of water and water-containing systems at these temperatures. Given the above data, therapeutic mud was used during the procedures with the temperature reduced to 35–36 °C, making it possible to reduce the body's heat load and the impact of changes in the structure of therapeutic mud.

The developed method [57] increased the rate of recovery processes. No adverse reactions were observed in any patient. The combined effect of the magnetic field and curative mud was more effective than the effect of curative mud during the treatment of osteoarthritis complicated by reactive synovitis. The effectiveness of treatment in the leading group was 90.7% and in control (curative mud) was 77%. The persistence of the therapeutic effect in the leading group was up to 1.5 years.

2.6. Assessment of the Therapeutic Effect of the Combined Effects of a Magnetic Field, Infrared and Light Radiation

Combined physiotherapy is based on the simultaneous action of two or more therapeutic physical factors on the same area of the body. The most crucial principle of combined physiotherapy is the principle of synergy [19]. For example, as shown above, the combined effect of a constant magnetic field and laser radiation when exposed to water gives a synergistic effect [20,21].

The synergistic effect of the simultaneous action of light radiation and a magnetic field has been discovered, particularly in studies of experimental dermatitis [58]. The studies show that photomagnetic therapy is more effective than phototherapy and magnetic field separately and leads to faster restoration of the typical structure of the skin. This effect of photomagnetic therapy has also been confirmed by clinical studies in dermatitis treatment [59]. The devices that use the combined effect of the magnetic field, infrared and light radiation have been used in the clinic for more than 20 years. However, using photomagnetic therapy in the complex treatment of 340 children with various diseases, the effectiveness of treatment varied from 83% to 92%, and in the control without photomagnetic therapy, the effectiveness of treatment was 55.7% ($p < 0.001$) [60].

Among the therapeutic effects of magnetophototherapy, anti-inflammatory, sedative, analgesic, antihypertensive, decongestant, antispastic, trophic-regenerative, and immune correcting effects [19,22,61] are of great importance.

2.7. Other Magnetic Field Effects

Under various effects of a magnetic field on water, an increase in plant productivity and composition [9,10,62–64] and an improvement in cement stone and concrete [65] have been observed. These data also indirectly indicate changes in the structure of water and water-containing systems.

3. Conclusions

Existing methods for assessing the structure of water and water-containing systems can be used to change their properties purposefully. For example, electrophysical research methods, determination of the electrical capacitance of water and water-containing systems at different frequencies, and dielectroscopy make it possible to assess the mobility of dipoles in various structural formations (including near-wall layers).

Thus, based on the results of the above studies, it can be concluded that when water and water-containing systems are exposed to light and magnetic fields, there are changes in their physicochemical parameters and, accordingly, changes in their structure and the structure of water.

Under the influence of a magnetic field on mineral water and therapeutic mud, there is also a change in their physicochemical parameters, biochemical parameters, and, accordingly, a change in their structure and the structure of the water. When treating mud and mineral water with a magnetic field, their therapeutic activity significantly increased. The effects of enhancing the recovery processes in the body under the influence of the combined effect of the magnetic field and natural healing factors are manifested both under the indirect action of the magnetic field through a change in the structure of mineral water and under the combined effect of the magnetic field and therapeutic mud.

Under various effects of a magnetic field on water, an increase in plant productivity and an improvement in their composition and an improvement in the properties of cement stone and concrete have been observed, which also indirectly indicates changes in the structure of water-containing systems.

Summarising the above, we can conclude that the impacts that change the structure of water and water-containing systems can lead to significant positive changes in the organism's state and the properties of non-living systems. In general, applying the modified structure of water and water-containing systems for creating a basis for new technologies in various areas of life is constantly expanding.

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