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EFFECTS OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELD AND MECHANICAL VIBRATION ON SPECIFIC ELECTRICAL CONDUCTIVITY OF DISTILLED WATER AND PHYSIOLOGICAL SOLUTIONS

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In present work the study of frequency-dependent effects of extremely low frequency electromagnetic field (ELF–EMF) and mechanical vibration (MV) on specific electrical conductivity (SEC) of distilled water (DW) and physiological solutions (PS) is described. The purpose of this study was to find out the frequency windows and demonstrate the dependency of these physical factors' effect on the environmental conditions. With this aim frequency-dependent (1–9 *Hz*) effect of ELF–EMF and MV (1 *h*) on SEC of DW and PS in light and normal background radiation (NBGR) has been investigated. As the "windows" have been observed only at 4 and 8 *Hz* the next experiments have been performed at this frequency. The experiments were carried out in the following media: in light ($E_v = 500-550\ lux$) and NBGR, in dark and NBGR (in wooden box), in dark and low background radiation (in lead box, $R < 1\ \mu R/h$) during 10 *min*.

Keywords: distilled water, physiological solutions, specific electrical conductivity, extremely low frequency electromagnetic field, mechanical vibration.

Introduction. At present, when the technological progress-induced environmental pollution the environmental health control becomes one of the most important problems of modern life sciences. From the beginning of the last century the structure of water (the dominant component of organism) was suggested as a universal target through which the biological effects of weak environmental factors on organisms are realized [1–3].

However, this statement did not meet an adequate application in estimation of biological effects of different environmental factors, including the extra-weak physical signals, having less intensity than thermal threshold. The main barriers for using structural characteristics of water as a marker for detection of safe doses of different environmental factors, are high variability of water structure and our weak knowledge on it. Since temperature, light intensity and background radiation are common physical components of environmental medium, the detailed mechanisms of their influences on water properties are also not fully clarified. Therefore, the purpose of present work is the study in light and normal background radiation (NBGR), in dark and NBGR and in dark and low background radiation (LBGR)

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induced effects on physicochemical properties of distilled water (DW) and physiological solution (PS) at 18^0C and 4^0C.

Specific electrical conductivity (SEC) estimates the amount of total dissolved salts, or the total amount of dissolved ions in the water. Any electrical conductivity observable in water is the result of ions of mineral salts, carbon dioxide (CO_2) dissolved in it and temperature. CO_2 forms carbonate ions in water. Water is self-ionized when two water molecules form one hydroxide anion (OH^-) and one hydronium cation (H_3O^+), but not enough to carry sufficient electric current to do any work or harm for most operations. In pure water, sensitive equipment can detect a very slight electrical conductivity of 0.055 *μS/cm* at 25^0C. The flowing water always has high electrical conductivity than standing one. After melting ice, the electrical conductivity is lower than that of initial water [4].

It has been maintained [5] that the treatment of fresh DW, DW in 3 days and DW in 6 days by static magnetic field (SEM, 2.5 *mT*, 1–100 *Hz*) and mechanical vibration (MV) (30 *dB*, 1–100 *Hz*) brings the decreasing effect of SEC. They have found that the effects of these factors on water after ice melting are less observed.

Materials and Methods. The experiments were performed on DW and PS for snail *Helix pomatia*. DW was obtained using water distiller device DE-4–2 *M* (State Standard 64-1–721-91, Moscow, Russia). PS had the following composition (*mM*): NaCl – 80, KCl – 4, $CaCl_2$ – 7, $MgCl_2$ – 27, Tris-HCl – 5.

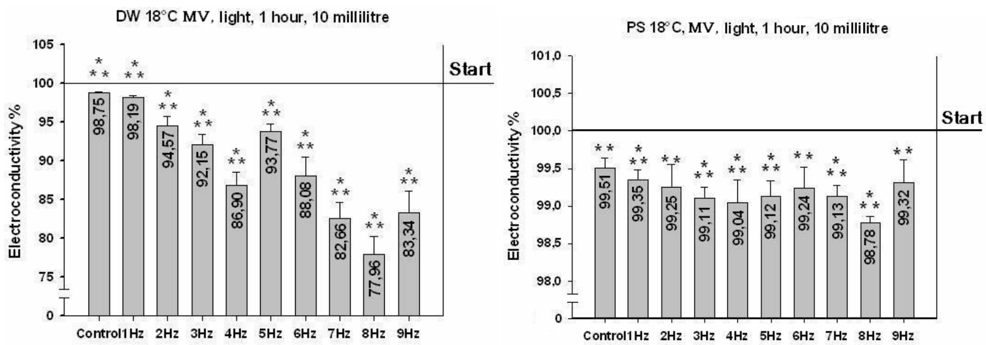
Before starting the experiments, fresh prepared DW and PS were stored in plastic container in lead box (E_v=0 *Lux* illumination, R<1 *μR/h* background radiation at $18\pm0.5\,^0C$ temperature) for 24 hours. After 24 *h* stabilization 2 fractions of each solution (DW – pH 5.8 and SEC $G=(4\pm0.12)\cdot10^{-6}$ *S/cm*, PS – pH 7.7–7.8 and $G=(95.56\pm3)\cdot10^{-4}$ *S/cm* (18^0C)) were taken and put in lead boxes at 18 and 4^0C for 2 *h* stabilization. Then, each fraction was divided into 3 samples (per 10 *ml*) to be exposed during 10 *min* in following 3 experimental media: a) *NBGR in light* (E_v=500–550 *Lux*) – which was considered as control; b) *NBGR in dark* (in wooden box, E_v=0 *Lux*) – which elucidated the effect of illumination; c) *LBGR in dark* (R<1 *μR/h*, in lead box) – which clarified the effect of background radiation. Then SEC of DW and PS were estimated accordingly. The wooden box was used for *NBGR in dark* exposition of DW and PS samples, while the *LBGR in dark* exposition were performed in the lead box (ВВСНХ ДС-ООО, Russia), having cylindrical form (height 32 *cm*, outside diameter 17.5 *cm*, wall thickness 4 *cm*, weight 50 *kg*).

The SEC of DW and PS sample (per 5–10 *ml*) was measured by conductometer Biophys-1 (elaborated by the IRPhE of NAS RA). The glass test tube with 15 *mm* diameter and 10 *ml* volume had two platinum electrodes inside, having 1 cm^2 surfaces separated by 1 *cm*, connected to the input of conductometer, was used as a testing electrochemical chamber. The temperature of aqua samples in test tube was controlled ($\pm0.1^0C$) by water jacket, connected to the thin thermostat BT-1 (Institute of Radiophysics and Electronics of NAS RA). Each experiment was repeated 10 times. For continuous recording SEC of DW and PS the output of measuring device was connected by Lab-Trax-4/16 data acquisition system (World Precision Instruments, Inc. Sarasota, FL, USA) to the PC.

The SigmaPlot 8.02 program for data analysis was used. The mean value and standard error of the mean (SEM) were calculated. The statistical probability was determined by Paired–Samples *t*-test and expressed in figures with the help of asterisks: * – $p<0.05$; ** – $p<0.01$; *** – $p<0.001$.

Results and Discussion.

The Frequency-Dependence (1–9 Hz) Effects of MV on SEC of DW and PS Samples at 18^0C. In Fig. 1 one can see that at all frequencies MV has depression effects on SEC of DW. However, two frequency windows were observed there, at which the MV has more valuable effects on SEC of DW than the neighbour frequency. One hour 8 *Hz* MV-treatment brings to decrease of SEC of DW by 22.04% comparing with the preliminary one (100%), while the same treatment by 4 *Hz* MV leads to decrease it by 13.1%.

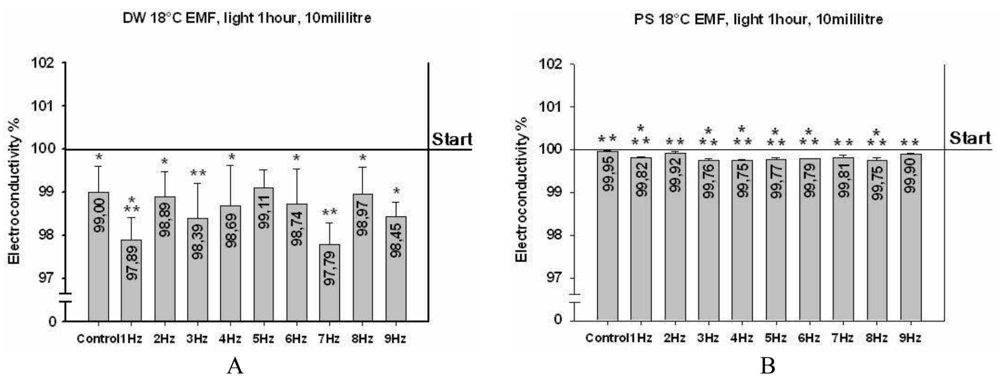


A B

Fig. 1. The frequency-dependent effects of MV (1–9 *Hz*, 1 *h*, 18^0C) on SEC of DW (A) and of PS (B).

The PS treatment by MV at 4 and 8 *Hz* was decreased SEC by just 1.22% and 0.96% comparing with the preliminary one correspondingly. Previously in our laboratory it was shown that the MV-induced decrease of SEC is due to evaporation of CO_2 solubility in DW [5]. Therefore, less expressed depressing effects of MV on PS could be explained by depressing variability of water clusters in electrolyte solution, which reduce carbon dioxide removal.

The Frequency-Dependent (1–9 Hz) Effects of ELF–EMF on SEC of DW and PS Samples at 18^0C.



A B

Fig. 2. The effect of ELF–EMF (1–9 *Hz*, 1 *h*, 18^0C) on SEC of DW (A) and of PS (B).

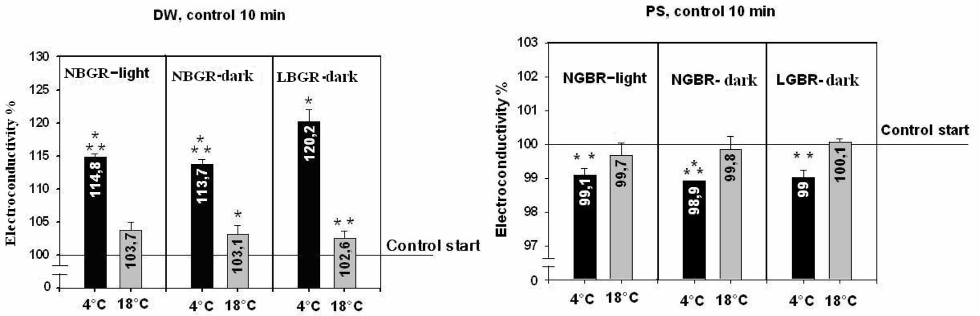
One hour treatment of DW and PS by ELF–EMF brings to SEC decrease. However, in case of MV the three frequency windows were observed: at 1 *Hz*

(2.11%), 3 *Hz* (1.61%) and 7 *Hz* (2.21%) (Fig. 2, A). The decreasing effect for 4 and 8 *Hz* ELF–EMF up to 0.25% comparing with the preliminary one (100%) (Fig. 2, B).

The Effects of Dark (LBGR and NBGR) and Light (NBGR) on SEC of DW and PS Samples at 18 and 4^0C. It is known that water molecules are constantly moving in relation are bound to each other and the hydrogen bonds are continuously breaking and reforming at timescales faster than 200 *fs*. Water has polar liquid properties, which is slightly dissociated disproportionately into hydroxonium ion – $H_3O^+_{(aq)}$ and associated hydroxide ions – $OH^-_{(aq)}$.

Therefore, the SEC of DW is mostly determined by these ions. As water density near 4^0C is the highest and clustered structure is less variable, it was suggested that the comparative study of water properties at 18 and 4^0C temperature will give possibility to estimate the role of water density in determination of its sensitivity to illumination and background radiation.

In Fig. 3, A and B illustrate the effect of dark (LBGR and NBGR) and light (NBGR) on SEC of DW and PS samples at 4 and 18^0C temperature: SEC is higher in case of 4^0C than at 18^0C.

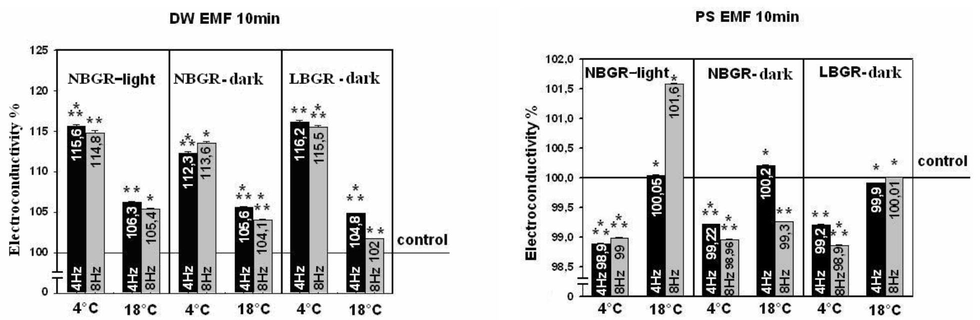


A B

Fig. 3. The effects of dark (LBGR and NBGR) and light (NBGR) on SEC of DW (A) and of PS (B) at 4 and 18^0C temperatures.

The less background radiation sensitivity of PS SEC compared with DW one, probably can be explained by the increase of aqua solution polarity, which makes its structure less flexible than structure of DW.

The Effect of ELF–EMF (4 and 8 Hz) on SEC of DW and PS in Dark (LBGR and NBGR) and Light (NBGR).



A B

Fig. 4. The effect of ELF–EMF (4 and 8 *Hz*) on SEC of DW (A) and PS (B) in light – NBGR, dark – NBGR and dark – LBGR.

The effect of 4 and 8 *Hz* ELF–EMF (10 *min*) on SEC of DW and PS in light – NBGR, dark – NBGR and dark – LBGR conditions was investigated (Fig. 4, A and B).

The Effect of MV (4 and 8 Hz) on SEC of DW and PS in Dark (LBGR and NBGR) and Light (NBGR). The effect of 4 and 8 *Hz* MV (10 *min*) on SEC of DW and PS in light – NBGR, dark – NBGR and dark – LBGR conditions it has been investigated (Fig. 5, A and B).

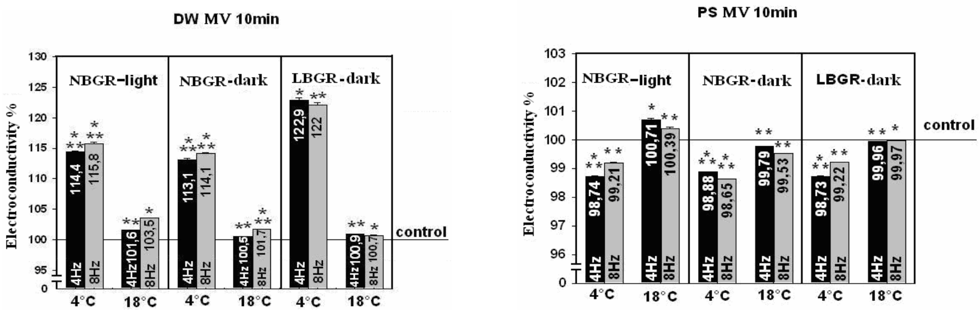


Fig. 5. The effect of MV (4 and 8 *Hz*) on SEC of DW (A) and PS (B) in light – NBGR, dark – NBGR and dark – LBGR.

It can be concluded that DW and PS at 4^0C illustrated more variable data than the data obtained at 18^0C.

Conclusion. There are frequency windows near 4 and 8 *Hz* frequencies effect MV and ELF–EMF on water conductivity. The MV and ELF–EMF induce changes of SEC of DW and PS depending on temperature, illumination and background radiation.

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