BACTERICIDAL EFFECTS OF LOW-INTENSITY EXTREMELY HIGH FREQUENCY ELECTROMAGNETIC FIELD: OVERVIEW WITH PHENOMENON, CELLULAR MECHANISMS, TARGETS AND APPLICATIONS

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Low-intensity electromagnetic field (EMF) of extremely high frequencies, a novel growing up and widely spreading environmental factor, has been revealed to have bactericidal effects. These effects and possible cellular mechanisms and target are reviewed.

Two types of low-intensity (the power flux density of 0.06 mW/cm^2) EMF of extremely high frequencies have been used in the study by different research groups for last years: “noise” EMF (of broadband frequencies and accidentally changing phases) usually of 45 GHz to 53 GHz, and coherent EMF (in time) of 42, 54, 66 and 78 GHz, 51.8, 53, 70.6 and 73 GHz frequencies, using the respective generators. Moreover, low-intensity EMF of extremely high frequencies has been applied to different bacteria such as *Escherichia coli*, *Enterococcus hirae*, *Bacillus firmus*, *B. mucilaginous*, *Staphylococcus aureus*, *Methanosarcina barkeri* and others. But, the coherent EMF has more interest.

The effects are revealed when a change can be measured in a biological system after introduction to EMF stimuli. The clear and reproducible effects of EMF at mentioned frequencies on *E. coli*, which is considered as the best characterized bacteria and a model organism have been shown well. The effects arise within tenths of minutes following EMF; the optimal exposure time is 1 h. In contrast, the other EMF frequencies such as of 41 GHz to 43 GHz, 61 GHz and 99 GHz have no sufficient effects on *E. coli*. On the other hand, EMF effect can be intensified with longer exposure period. As it was shown for 99 GHz, EMF effect accumulates in cell and reveals at higher exposure times.

Among cellular mechanisms of these effects of low-intensity EMF at its resonant frequencies, different targets are of significance: (1) the liquid environment, especially water (H_2O), since the changes in its cluster structure and properties (pH, absorbance, electro-conductivity etc) leading, for instance, to increase chemical activity of H_2O or hydration of proteins and other cellular structures have been determined, and these effects might be specific and long-term; (2) the bacterial membrane, since the changes in surface characteristics, substances transport across membrane, energy-conversing processes, proton-coupled enzymatic activity have been revealed; (3) the bacterial genome, since conformational changes in DNA and transition of bacterial pro-phages from lysogenic to lytic state have been detected. The question still under debate is whether there are other interaction mechanisms and targets in cells.

EMF interaction with bacteria is of significance to change their sensitivity to different chemicals, including antibiotics and especially of membranotropic action.

The effects of low-intensity extremely high frequencies EMF are important to understand distinguishing role of bacteria in environment, leading to changed metabolic pathways and, for instance, antibiotics resistance. EMF may also affect cell-to-cell interactions in bacterial populations, since bacteria might interact with each other through EMF of sub-extremely high frequency range. Due to bactericidal effects, this EMF might be applied in food industry, medicine and veterinary.

БАКТЕРИЦИНЫЕ ЭФФЕКТЫ ЭЛЕКТРОМАГНИТНОГО ИЗЛУЧЕНИЯ КРАЙНЕ ВЫСОКИХ ЧАСТОТ МАЛОЙ ИНТЕНСИВНОСТИ: ОБЗОРНЫЙ ВЗГЛЯД НА ФЕНОМЕН, КЛЕТОЧНЫЕ МЕХАНИЗМЫ, МИШЕНИ И ПРИЛОЖЕНИЯ

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За последние годы выявлены различные бактерицидные эффекты электромагнитного излучения крайне высоких частот (ЭМИ КВЧ) малой интенсивности. Приводятся типы ЭМИ КВЧ, применяемые частоты и мощности, а также виды бактерии, на которых показаны эффекты. Эти эффекты и возможные клеточные механизмы и мишени обобщаются. Среди мишеней рассматриваются вода, бактериальная мембрана и геном.

Обсуждаются значение воздействия ЭМИ КВЧ в природе, возможности использования бактерицидных эффектов в практике.