BIOTROPIC PARAMETERS OF ELECTROMAGNETIC RADIATION FOR REGENERATION OF ANIMAL DAMAGED BONE TISSUE

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Abstract. *The development of effective medication-free treatment and means of animal injuries treatment is urgent task. The optimal parameters of electromagnetic field of ultra-high frequency range interacting with the bone tissues of animals have been determined. The aim of the work is to identify the high-frequency range of the electromagnetic field parameters in interaction with animal tissues using the developed mathematical model. The dependence of electric component amplitude of magnetic frequency field was investigated. It has been proved that the dimensions of the limbs and internal tissues significantly affect the internal distribution of the electromagnetic fields. The results of experimental studies have made it possible to determine the optimal frequency, power and radiation source arrangement for the injury treatment of different animal species. The application of electromagnetic radiation with optimal parameters intensifies metabolism on the diseased cells membrane level and assists more rapid recovery of the injured bone tissue.*

KEYWORDS: *INJURIES, ULTRA-HIGH FREQUENCY, PARAMETERS, MATHEMATICAL MODEL, METABOLISM, CELLS MEMBRANE*

1. Introduction

Nowadays, one of the important tasks facing Ukraine's agrarian complex is increase of livestock farming productivity while keeping heard expansion of domestic animals, which depends on efficient animal disease treatment, in particular traumatism.

Animal traumatism is the common group of diseases among all non-contagious diseases amounting to 50% of total disease rate [1].

Now medicaments are mainly used for treatment of animal injuries. In most cases application of antibiotics and other medicated things is not efficient enough and unsafe, it blocks the disease symptoms. Getting into the human organism via livestock products, antibiotics have negative influence on it, suppress the immunity, contribute to mutated virus replication causing various diseases [1,2].

Therefore, the development of efficient medicament-free treatment and development of technical means for animal injury treatment is actual one.

2. Results and Discussion

The data analysis of numerous researches and publications [2] has allowed to state that one of the prospective ways of medicament-free treatment of animal injury is the impact of electromagnetic field (EMF) of LHF-range.

The research aim was on the basis of the developed mathematical model [3, 4] to define the biotropic parameters of electromagnetic field of LHF-range during its interaction with animal tissues.

Applying the obtained [3,4] mathematical expressions, the numeric computations of the biotropic parameter values of the electromagnetic field in animal limbs of different geometric dimensions have been made; the optimal frequency of impact which allows to give the appropriate recommendations on technical features of the developed therapeutic apparatus has been defined.

The fundamentals of the computations were the mathematical values [3, 4], which describe the distribution of electromagnetic wave of LHF-range on a biological object of cylindrical shape with layered structure by radius:

$$\dot{E}^{i}_{z\,\mathrm{pad}} + \dot{E}^{i}_{z\,\mathrm{otr}} = \sum_{m=0}^{\infty}\left[\dot{B}^{i}_{m}\, J_{m}\left(k_{i} r\right) + \dot{C}^{i}_{m}\, H^{(2)}_{m}\left(k_{i} r\right)\right]\cos\left(m\varphi\right)$$

where $\dot{E}^{i}_{z\,\mathrm{pad}}$ – tangential component of incident electromagnetic wave for the i-layer, W/m; $\dot{E}^{i}_{z\,\mathrm{otr}}$ – tangential component of reflected electromagnetic wave for i-layer, W/m; $J_m\left(k_i r\right)$, $H^{(2)}_m$ – according to Bessel function of the first kind and Hankel function of the second kind of m-harmonic; k_i – wavenumber for i layer, $k_i = \omega\sqrt{\varepsilon_i \mu_0}$: ε_i – dielectric permittivity of i layer; ω – angular frequency of given radiation, s^{-1}; μ_0 – magnetic permeability of the air, Gn/m; r – the coordinate on the cylinder radius $\left(0 < r < R\right)$; $\dot{B}^{i}_{m}, \dot{C}^{i}_{m}$ – fixed coefficients [4]; $\cos\left(m\varphi\right)$ – Legendre polynom.

According to the obtained expressions the amplitudes of inner fields are complex values which change their phasing depending on animal limb dimensions, incident frequency, electro-physical characteristics of biological tissues and their location inside a limb.

The zeroth harmonic of incident electromagnetic field (the amplitude of harmonics with numbers m >1 is significantly lower than the zeroth one) makes the major influence on an animal limb, which is connected with low resonance characteristics of biological objects being exposed to radiation.

Electromagnetic characteristics of all five layers taken into account [4] were chosen according to reference data. The intensity of the incident field electrical component equals one, which allows going to any concrete value Eo in calculations, at the same time the case of E-polarization is considered.

The mentioned review of literature data [2] indicates that the main curative effect of electromagnetic radiations in case of bony pathologies is connected with their effect on cell membranes and the activization of ion movement of different microelements through them. At the same time characteristic resonance frequencies of these processes are within the range of 10^9-10^{11}Hertz.

Taking into account that during passing of electromagnetic radiations of decameter and centimeter range through an animal limb, on the one hand, there is the radiation absorption, on the other hand, there is their resonance re-scattering on different biological inhomogeneity; first of all, it is necessary to determine at what frequencies the electromagnetic field component strength will be maximum in bone marrow of bony tissue.

According to the aim we have studied the dependence of EMF electric component amplitude on frequency in the area of bone marrow and bony tissue of a limb. To obtain the more universal animal treatment methods the limbs of large animals (a horse, a cow) as well as small ones (a pig, a sheep) were examined. It was done due to the fact that both cross-sectional geometric shapes of limbs and sizes of their internal tissues differ significantly, so this could affect the distribution of inside electromagnetic fields in them.

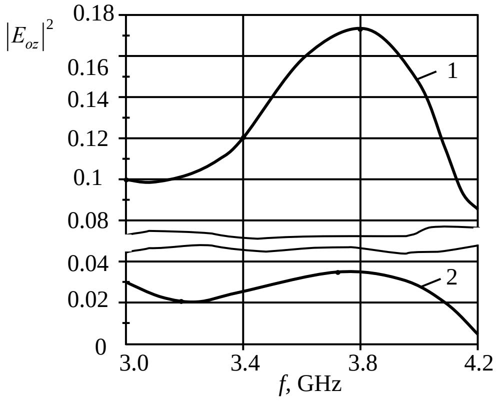

***Fig. 1** – The square of amplitude of EMF electric component $|E_{0z}|^2$ versus frequency response f for a pig leg: 1 – in bone; 2 – in bone tissue area marrow area*

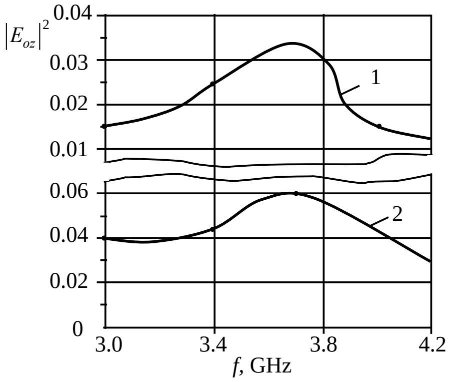

***Fig. 2** – The square of amplitude of EMF electric component $|E_{0z}|^2$ versus frequency response f for a cow leg: 1 – in bone marrow area; 2 – in bone tissue area*

In picture 1 there are the results of calculations performed within the range of 3.0-4.2 GHz for a pig leg. Picture 1 (curve 1) shows that in the area of bone marrow the maximum value of the electric component is at a frequency of 3.8 GHz. At frequency shift to the left and right from the identified frequency there is the amplitude loss. The same has to be said about the curve 2, where the same response is presented but for the area of bony tissue. In this case the maximum amplitude is at a frequency of 3.7 GHz. However, the shift into more longwave range affects the field value less than the shift into more shortwave range.

In picture 2 there are curves corresponding to frequency dependence of square for inside field electric component amplitude for a cow leg. It should be mentioned that in this case in the area of bone marrow as well as in the area of bone tissue of a leg the maximum is weaker than for a pig. This is explained by large sizes of a leg and correspondingly the length of incident electromagnetic wave. Therefore, resonance phenomena are weaker. However, in this case the electric component reaches its maximum at the range of frequencies of 3.6 – 3.7. GHz.

According to the obtained results we can conclude that the most acceptable value for radiation of injured legs of farm animals is the frequency within 3.7 GHz from the view of electrodynamics. In addition, the proper location of maximum of effecting field allows to choose the radiation sources with less power flows that is very important for treatment.

It should be emphasized that in the present graphs along the axis of ordinates there is a dimensionless value indicating which part of incident electromagnetic radiation strength reaches the particular area of an injured leg.

Having identified the most acceptable radiation frequency of electromagnetic field, the examination of its distribution in cross-section cut of an injured limb was carried out; it was necessary to determine how efficient was the field affecting the proper injured areas of legs.

In order to get the result, the radius of cross-section cut of leg versus E_{0z} was examined on the basis of its anatomic organization.

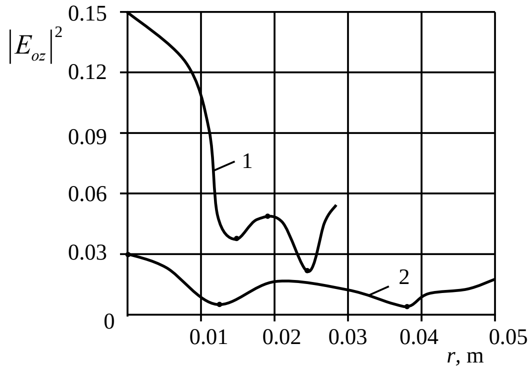

***Fig. 3** – Distribution of amplitude square of electric component of electromagnetic radiation inside animal limbs at a frequency of 3.7 GHz: 1– for a pig; 2– for a cow*

In picture 3 (curve 1) there is the dependence of amplitude square of longitudinal component of electric field on a leg cross-section cut radius inside a pig limb. The chosen radiation frequency was equal to 3.7 GHz. According to the picture in the both areas of bone marrow and bony tissue the electric field is more powerful than in other areas. Thus, we have to conclude that radiation at this frequency will have maximum effect on the injured bony tissue and assist its fast recovery.

According to figure 3 (curve 2) illustrating the distribution of electric component $|E_{0z}|^2$ in cross-section cut of a cow leg at a frequency of 3.7 GHz there is the similar result. In this case density of the field is located in the areas of bone marrow and the injured bony tissue.

Thus, despite an animal size (a pig, a cow) the radiation at identified frequency in particular has the maximum stimulating effect on cambiogenetic hardness, cortical layer of bone and soft tissues around the fracture.

The similar results obtained after calculations for limbs of other farming animals (a horse, a sheep) indicate that the most acceptable value of electromagnetic field applied for therapeutic reason during the treatment of limb injuries of different animals is the range from 3.7 to 3.8 GHz. This range is acceptable from the view of obtaining the optimal amplitudes of EMF inside the objects exposed to radiation as well as from the view of optimal distribution of inner field.

Taking into account the above calculations it may be concluded concerning the flow density strength of radiation for an injured limb. According to literature sources, radiation strength at 0.1 mW/cm^2 causes the appearance of membrane cells of the identified potentials, which has positive influence on the transmembrane ion movement. In other words, there is an intensive recovery process for diseased and injured cells. Thus, the radiation source has to create the exact flow density strength in the places of injury.

Taking into account the results (see pics. 1-3) demonstrating which part of radiation strength reaches the injured area (0.005-0.01) and the identified above the necessary strength level for curing effect, it may be defined that the radiation source has to radiate approximately at 100 W/m^2.

3. Conclusions

On the basis of proposed theoretical model, the performed computations have indicated that the most acceptable frequency of electromagnetic radiation for limbs of different farming animals is 3.7-3.8. GHz. In this case the field distribution by limb cross-section cut and its amplitude are the most optimal ones.

According to the results the radiation has to be of 100 W/m^2. This intensifies the metabolism in membranes of sick cells and encourages the fastest recovery of injured bony tissue.

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