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Features of Low-Intensity Energy Balance in the Process of Physiotherapeutic Application of Mixtures of Natural Materials

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The authors investigated the features of energy balance that provide the process of using natural materials in physiotherapeutic thermal procedures. Substances such as ozokerite, paraffin, naphthalene, muds and their combinations are widely used in physiotherapy, so it is important not only to know the parameters of the heat exchange, but also the distribution of other types of energy that can affect the effectiveness of treatment. The authors theoretically substantiated and experimentally proved that microwave component is presented in the radiation spectrum of the ozokerite applicator. The level of radiation in the millimeter range of the applicator with a size of 10×10 cm is compared with the level of low-intensity signals of technical devices for millimeter therapy. The dynamic change of the radiation level of the microwave component during the cooling of the applicator from the maximum temperature of 50°C to the temperature of the human body surface was investigated. It was revealed that the sign of the radiation of the millimeter component in relation to the human body changes. This results in the formation of positive and negative low-intensity flows of microwave radiation. The frequency ranges of these flows and their level were investigated. It has been found that changing the percentage of paraffin in ozokerite can affect the level and range of negative microwave flows. The results of previous studies by the authors, which substantiate the positive effect of negative flows, including ozokerite-paraffin therapy, in inflammatory processes with "excess energy" and other diseases, are adduced. The microwave electromagnetic radiation studied by the authors is a concomitant factor during the relevant physiotherapeutic procedures, in particular heat treatment. However, this factor can significantly affect the functional state of the human body, so it must be taken into account during physiotherapy procedures.

Key words: microwave radiation; negative and positive flows; physiotherapy procedure; ozokerite-paraffin mixture

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Introduction

Heat treatment is one of the most common physiotherapy procedures. It uses a variety of natural materials, including peloids (therapeutic muds of different composition), minerals (lithotherapy), peat, sand, as well as derivatives of oil and oil fields naphthalene, ozokerite, paraffin, which are a mixture of high molecular weight hydrocarbons and are most often used in physiotherapy procedures [1–4]. Among these materials in terms of thermophysical characteristics, in particular, heat capacity, thermal conductivity and heat retention capacity, ozokerite and paraffin are most suitable for physiotherapy procedures.

For example, the heat retention capacity, which characterizes the delayed heat transfer of paraffin, is 1190 sec, and ozokerite 1975 sec, which is 2-4 times more comparing to the heat retention capacity of other natural materials. The heat capacity of these materials is compared with the values of common natural materials, and the thermal conductivity of ozokerite, as one of the main parameters of heat treatment, is $0.17\,\mathrm{W/(m\ ^\circ C)}$, which is 2 to 5 times less than the thermal conductivity of other materials and 1.5 times less than paraffin [3, 5].

The applicators from both pure paraffin and its mix with other materials for increase of the plasticity are usually used in heat treatment. High heat capacity, low thermal conductivity, almost complete absence of convection component of heat exchange, as well as the ability to release large amounts of heat during hardening and create compression pressure at the application site are significant advantages of paraffin as a coolant (the same property is inherent in ozokerite). The positive properties of paraffin should also include its chemical neutrality. At the same time, the microwave properties of paraffin, which occur during its heating and affect the course of energy metabolism between the objects of therapy, have not been studied.

From the group of materials for physiotherapy ozokerite should be singled out. It is used alone or in a mixture, the proportion of which can be up to 90%. In addition to significant heat capacity, high heat retention capacity and the lowest thermal conductivity, ozokerite has a multi-component chemical composition, which includes ceresin up to 85%, paraffin in the range of 3-7%, petroleum oils up to 10% and other bituminous substances [1]. This composition of ozokerite, in addition to thermal and mechanical action, also causes a chemical effect on the human body. The highest heat capacity, heat retention capacity and the lowest thermal conductivity cause high efficiency of this material for physiotherapy. Therapeutic effects that occur primarily include anti-inflammatory and vasodilating effects, as well as acetylcholine-like, estrogen-like and chemical effects of ozokerite [1, 3]. However, the features of low-intensity energy balance and microwave properties of the material, which occur when heated and also have an impact on the human body, need to be studied.

1 Relevance of the topic and analysis of recent achievements

In the technology of physiotherapy, the specialized medical literature identifies three main factors that arise and affect the treatment area, and through it the patient's body as a whole: thermal, mechanical and chemical [1, 2, 4, 5]. The main is the thermal (heat) factor due to the phenomenon of thermal conductivity, but in the structure of the energy balance there are significant microwave factors. Therefore, the as reason for the positive therapeutic effect in the implementation of therapeutic procedures can be considered not only the thermal process, but also related microwave radiation, which requires to be studied and investigated.

It is known from physics that the heating of any dielectric physical body is accompanied by electromagnetic radiation (EMR) in a wide range of frequencies. Moreover, its spectrum is noise-like, and the intensity for the temperatures characteristic of physiotherapy is small (up to 10^{-21} W/Hz cm^2). At the same time, it is known that low-intensity EMR of different parts of the electromagnetic spectrum has a significant impact on biological objects, and therefore is used in microwave (millimeter) therapy at frequencies 30...120 GHz, low-level light therapy (LLLT) and other technologies to influence biologically active points (or zones) and some areas of the skin surface of patients in order to normalize the human body state [5, 7]. The study of energy balance and structure of microwave radiation of some objects and the human body is reflected in the works of the authors [6, 8].

Since low-intensity microwave radiation (at the level of $1 \cdot 10^{-9} \dots 1 \cdot 10^{-12}$ W) has a significant impact on biological objects and the environment, it is the subject of recent research not only in Ukraine but also abroad [6, 8–11]. These studies have intensified in connection with planetary and man-made electromagnetic pollution from the introduction of new millimeter-range telecommunications systems [12].

The aim of the article is to conduct theoretical and experimental studies of the emissivity of ozokerite, paraffin and their mixtures in the millimeter wavelength range. As mentioned above, microwave electromagnetic radiation is a concomitant factor during appropriate physiotherapy procedures, in particular heat therapy. This factor can significantly affect the functional state of the body (see [6]). Therefore, it is advisable to determine the ratio of own EMR of the materials for physiotherapy and the patient's body, primarily in the millimeter wavelength range and take it into account when conducting physiotherapy procedures.

2 Theoretical data of the study

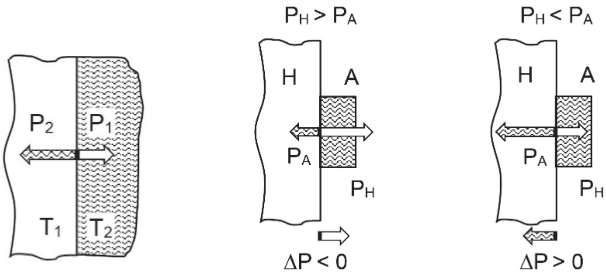
From the point of view of physics, the process of heat treatment should be considered as a violation of thermodynamic equilibrium in the system, which includes the area of each human body surface and the applied applicator. Energy exchange in any system, parts of which have different temperatures, as it's known, can be carried out through processes of thermal conductivity, convection and radiation. In our case, convection can be ignored, and the energy exchange between the surfaces of the applicator and the skin of the patient is carried out mainly due to the phenomena of thermal conductivity and electromagnetic radiation.

The temperature distribution is described by the equation of thermal conductivity with certain boundary conditions, and the flow of thermal energy (thermal power, W) is represented by the well-known Fourier law

$$P = \lambda \operatorname{grad} T \cdot \sigma_0, \qquad (1)$$

where λ — the thermal conductivity of the applicator or biotissue (skin); $\operatorname{grad} T$ — temperature gradient between ozokerite-paraffin applicator and skin; σ_0 — the square of the surface perpendicular to the flow direction.

Figure 1a shows two arbitrary objects, or the applicator and the patient's body, that are in thermal contact. In a state where the thermodynamic equilibrium is disturbed ($T_1 \neq T_2$) and the power of the heat flows P_1, P_2, is not balanced, the direction of energy transfer depends on the temperature. For example, if the patient's temperature is higher than the applicator temperature (cooling applicator), the flow of heat energy will be directed from the patient's skin and can be considered negative in relation to the person (Fig. 1b)



(a) (b) (c)

Fig. 1. Distribution of energy flows between arbitrary objects (a) and paraffin-ozokerite mixture in relation to the patient's body: b) negative energy flow; c) positive energy flow; H — patient's body; A — applicator; P_H — the patient's energy flow; P_A — energy flow of the applicator

$$\Delta P = P_A - P_H < 0,$$

where P_A – patient's energy flow, P_H - energy flow of the applicator.

If, on the contrary, the applicator is heating, as in the case of heat treatment, the flow will be directed to the patient, and it can be considered positive (Fig. 1c)

$$\Delta P = P_A - P_H > 0.$$

At the same time, it is known that, when heated, any physical body emits electromagnetic waves in a wide range of frequencies. Such thermal radiation has a noise-like character, and the distribution of its energy density by frequency is described by Planck's law [13].

To determine the power level of the millimeter part of the microwave range, which can significantly affect the state of a live organism [5, 8], you can use the Rayleigh-Jeans formula for thermal radiation of an absolutely black body (ABB). In this case, the radiation power from the surface of the body σ_0 in the frequency range Δf for three-dimensional objects is defined as

$$P = 2\pi\beta\,(f,T)\,\frac{f^2}{c^2}kT\sigma_0\Delta f, \tag{2}$$

where $k = 1,38 \cdot 10^{-23}$J/K - Boltzmann constant; T - radiating body temperature; f - radiation frequency ($f \gg \Delta f$); $\beta\,(f,T)$ — the coefficient of emissivity of the object (for ABB $\beta = 1$).

If a radiometric system (RS) is used to record such radiation, its output signal will be proportional to the temperature difference between the object of study and the RS itself, ie excess power

$$\begin{aligned}\Delta P = {} & 2\pi K_1(f)\,\beta(f,T)\,\frac{f^2}{c^2}k\,(T - T_R)\,\sigma\Delta f = \\ & = K_1(f)\,\beta(f,T)\,k\,(T - T_R)\,\Delta f,\end{aligned} \tag{3}$$

where $K_1(f)$ — coefficient of the conversion of the receiving antenna, which also takes into account the influence of the radiation source; T_R — temperature of the radiometric receiver.

At the same time, in the field of radiological measurements, the Nyquist formula is used to estimate the receiver's own noise level and the output power of waveguide noise generators, which is converted to formula (2) for one-dimensional objects and the conformed load can be considered as a kind of equivalent of a absolutely black body. Thus, the waveguide RS for the analysis bands Δf, provides measurement of microwave power generated by a source of thermal radiation, the level of which is determined by the formula (3).

In the case of differences in the emissivity of the applicator and human skin, ie the coefficients β_A and β_H, differ, between them there is an exchange of electromagnetic energy. The power of microwave energy flows, which are indicated in Fig. 1, can be determined by formulas:

$$P_H = \beta_H(f,T)\,k\,(T_H - T_R)\,\Delta f,$$

$$P_A = \beta_A(f,T)\,kT_A\Delta f,$$

and accordingly, the resulting flow

$$\Delta P = (\beta_H - \beta_A)\,kT\Delta f.$$

Thus, depending on the ratio of temperatures T_A and T_H, so as coefficients β_A and β_H in relation to the area of the human body, both negative flow can be realized when the applicator emits less than the patient's skin (Fig. 1a), and positive when the opposite (Fig. 1b).

At the same time, it is known that the authors [15] proposed a method of instrumental treatment using negative and positive low-intensity flows and conducted its laboratory and clinical trials. To perform such studies and provide the formation of multi-vector energy flows, a high-temperature noise generator "Porig VT" and a low-temperature noise generator "Porig NT" were used. Experimental laboratory studies were performed on the basis of the Kyiv Oncology Institute of the Ministry of Health of Ukraine by irradiating of subcutaneously inoculated sarcoma C-37 to three groups of white outbred mice (10 animals in each group) [15]. One of the groups served as a control.

Exposure was 3 minutes each day for 10 sessions. During the experiment, the indexes of peripheral blood of animals, the process of tumor growth, - the size and weight of the tumor - were evaluated. As a result, positive flows were found to stimulate tumor growth by 13.5%, and negative flows inhibited tumor growth by 27.4%.

As a result of clinical trials of the developed method on two groups of patients with gastrointestinal diseases the increase of efficiency and reduction of time in comparison with other methods of treatment of gastrointestinal diseases is established, with confirmation of results by endoscopic inspection [14]. The treatment method of the musculoskeletal system diseases and the equipment for it proved to be perspective. Positive effect of treatment was shown in removal of pain syndrome and permanent consolidation of this positive effect [6, 15].

3 Features of microwave radiation formation of the ozokerite-paraffin applicator

The peculiarities of the formation of microwave radiation with ozokerite-paraffin applicator include the fact that its emissivity β_A is determined by the angle of dielectric loss δ_A and dielectric constant ε_A of the components of the mixture: ozokerite and paraffin, which depend on temperature [16]. It is also necessary to take into account the peculiarities of the frequency dependence of these values in the millimeter range, which are observed for both physical materials and biotissues [16]. Moreover, the coefficient of emissivity of the applicator is a function of two variables $\beta_A(f, T)$, and the coefficient of the emissivity of human depends only on one variable $\beta_H(f)$, and their dependences on frequency differ. All this greatly complicates the theoretical analysis of the energy balance during the interaction of the studied objects.

Taking into account the specifics of physiotherapy procedures, the emissivity of the ozokerite-paraffin applicator in the microwave range for a certain temperature T, according to formula (3), it is advisable to evaluate the excess integrated power in the frequency band Δf, measured by the radiometric system

$$\frac{\Delta P_A}{\Delta P_H} = \frac{\beta_A\,(f,T)\,(T_A - T_{\mathrm{PC}})}{\beta_H\,(f)\,(T_H - T_{\mathrm{PC}})}, \qquad (4)$$

where ΔP_A, ΔP_H – integrated power of radiation in the frequency band Δf respectively the applicator and the surface of human skin in the operating frequency band of the radiometric receiver.

Given the above and the lack of literature data on the presence and level of the microwave component of the considered materials, which has a significant impact on biological objects, the authors conducted an experimental study of the emissivity of ozokerite-paraffin mixture, taking into account the treatment protocol.

4 Equipment and methods of research

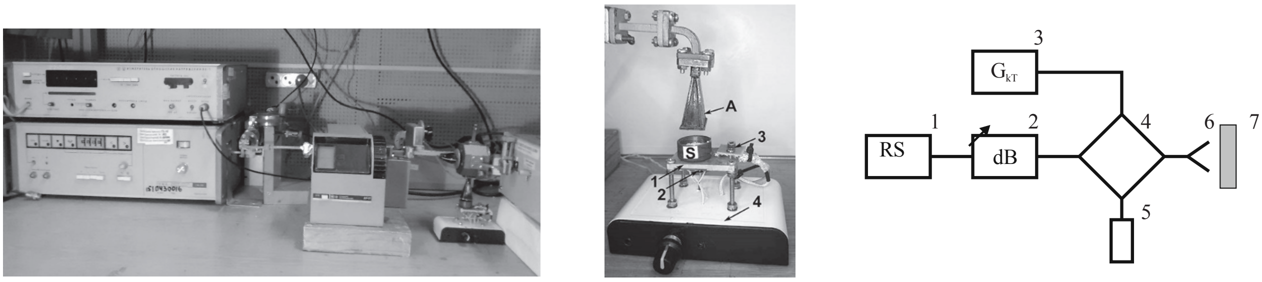
Studies of radiative ability in the millimeter range were conducted using materials that are most often used in medical institutions of Ukraine – ozokerite from the Boryslav deposit of Lviv region (JSC "TD Ekomed", date of manufacture January 2019), as well as purified paraffin pharmaceutical packaging.

Determination of microwave parameters of selected materials, taking into account the noted features of physical bodies when heated, was carried out according to the following method. The test material was placed in a metal container of cylindrical shape with a radius of the size of the horn receiving antenna. The temperature of the container with the material was maintained using a portable thermostat with an accuracy of ± 0.25°C. The temperature was chosen in the range from 36°C to 50°C (maximum value provided by the method of treatment). Measurement of excess EMR power of samples of materials in containers was performed using a highly sensitive radiometric system with a sensitivity threshold of not more than $3{\cdot}10^{-14}$ W in the frequency range 38…52 GHz. The frequency band Δf, analyzed by this system, was approximately 0.1 GHz [8]. The appearance of the experimental setup is shown in Fig. 2a.

Fig. 2b shows the input part of the experimental setup. During the measurements, the receiving antenna A was placed in close proximity to the container with a sample of ozokerite-paraffin mixture S. Moreover, the container was installed on the plate 1 of the portable heater-thermostat 2 with the sensor 3. Using the controller 4, the temperature of the plate 1 was pre-set the desired temperature of the experimental sample.

Fig. 2c shows a functional diagram of the experimental setup. The input 1 of the radiometric system through the precision attenuator 2 by means of a waveguide switch 4 was connected to the output of the antenna 6, which received the radiation of experimental sample 7, as well as to the reference noise generator 3 [8] and the agreed load 5.

This allowed, firstly, to control the zero deviation of the RS, and secondly, to determine the absolute value of the excess integral power ΔP of the electromagnetic radiation source using a G_{kT} generator, which can be considered "absolutely black body" in the specified frequency range, with the possibility of setting its own temperature from 20 to 70°C. The used method of the measurement allowed to determine the power with an error of approximately 10%.



(a) (b) (c)

Fig. 2. Appearance of a highly sensitive radiometric system for assessing the emissivity of materials in the microwave range (a, b) and its functional diagram (c)

For example, the average value of the excess integrated radiation power of the human palm was $\Delta P_H = (5 \pm 0,5)\cdot 10^{-14}$W, which corresponded, taking into account the area of the aperture of the measuring antenna, the density of the flow of $2{,}5\cdot10^{-14}$ W/cm^2.

The process of research and evaluation of microwave properties of materials was carried out taking into account the peculiarities of the technological cycle of treatment. The following parameters and characteristics were measured:

- the average level of radiation on the surface of human skin (palms of three respondents);
- changes in radiation levels, with the repeated use of ozokerite during treatment with the addition of fresh material;
- radiation level of pure ozokerite and paraffin at the maximum therapeutic temperature of materials (+50°C);
- changes in the power level of EMR materials during their cooling;
- EMR power level of ozokerite depending on the percentage of paraffin impurities;
- comparison of the emissivity of materials with the average level of radiation of the human body and the output power of the thermal noise generator [8].

5 Evaluation of measurement results and research

1. EMR power measurements were performed at a frequency of 52±0,1 GHz with an analysis band of 100 MHz. For comparison, the average radiation power level of the human palm surface (limited antenna aperture plane 2 cm^2) was determined for three respondents, which was $P_H = (4,5 \pm 0,5) \times 10^{-13}$ W or, accordingly, taking into account the area of the measuring antenna aperture, density of the flow $2{,}25\cdot10^{-13}$ W/cm^2 .

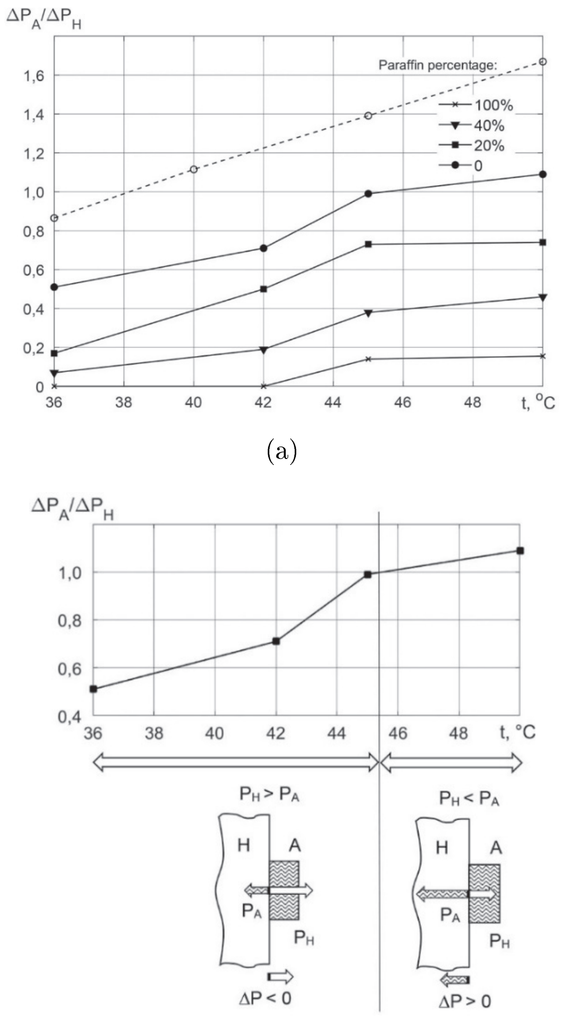
2. According to the recommendations, the course of treatment usually consists of 10 sessions, and before each session to the previously used material is added 25% fresh. Studies of the electromagnetic properties of the selected samples showed that the addition of fresh portions of ozokerite at different stages of treatment did not significantly affect the parameters of EMR.

3. Fig. 3a shows the temperature dependences of the electromagnetic radiation power of the ozokerite-paraffin mixture ΔP_A, with different percentage impurities of paraffin relative to the above value ΔP_H. The dotted line shows a similar characteristic for the reference noise generator G_{kT} (ABB). Paradoxical, at first glance, the excess of human radiation compared to ABB can be explained by the possible nonequilibrium radiation associated with biochemical processes in the human body, as well as to some extent the measurement error.

4. The absolute values of the EMR power level were determined using a certified reference noise generator, which is part of the radiometric system. The results of measurements at a maximum therapeutic temperature of 50°C (Fig. 3a) show that the level of radiation of pure ozokerite is slightly higher than in the human palm. At the same time, the level of EMR of pure paraffin at the same temperature does not exceed 20% relative to the level of radiation of human skin. This can lead to the formation of a negative EMF flow, the intensity of which increases with increasing percentage of paraffin in the mixture with ozokerite.

The graph of the temperature dependence of the power of its own radiation of pure ozokerite during its cooling, presented in Fig. 3b, shows that change in temperature can lead to a change in the redistribution of electromagnetic energy between the applicator and the skin. Thus, on the graph, in the temperature range from 50°C to 46°C, a positive flow ($\Delta P > 0$) is formed, and in the temperature range from 45°C to 36°C a negative flow ($\Delta P < 0$) of microwave radiation.

After analyzing the graph in Fig. 3a, it can be concluded that basically all percentage mixtures of ozokerite and paraffin contribute to the formation of negative flow of electromagnetic radiation in the millimeter range. In this case, the physiological effects characteristic of heat treatment will also be accompanied by effects caused by negative flow [5, 16], in particular, anti-inflammatory action.



(a)

(b)

Fig. 3. Dependence of relative power of radiating ozokerite-paraffin mixture on temperature (a) and distribution of electromagnetic energy flow for ozokerite applicator (b)

Conclusions from the results of the study

1. Experimental studies have shown that ozokerite, paraffin and its mixtures form low-intensity electromagnetic radiation in the millimeter range. This factor, together with the thermal effect, affects the patient's body, creating and enhancing the therapeutic effect.

2. Depending on the temperature, the pure ozokerite applicator, at the maximum temperature, forms a low-intensity positive flow of EMR. Decreasing the applicator temperature to less than 45°C results in a negative EMF flow, the intensity of which increases with further cooling. The total power of the ozokerite applicator, for example, with a size of $100\,\mathrm{cm}^2$ may be about $3{\cdot}10^{-11}$ W, which coincides in magnitude with the low-intensity levels used in millimeter therapy [6, 8, 15].

3. The use of ozokerite-paraffin mixture with a paraffin content of more than 10% in the range of recommended therapeutic temperatures leads to the formation of a negative flow of EMR, which increases with increasing percentage of paraffin in the mixture.

4. Experimental studies of EMR of the materials for ozokerite-paraffin therapy have shown the complexity of electromagnetic microwave processes that affect and interact with the electromagnetic field of the human body and require their consideration in physiotherapy.

References

[1] Vladymyrov O. A., eds. *Fizioterapiia: pidruchnyk* [Physiotherapy: a textbook]. Kyiv, Format, 2013. 432 p. [In Ukrainian].

[2] Ponomarenko G. N., eds. *Fizioterapija: Nacional'noe rukovodstvo* [Physiotherapy: a national guide]. Moskow, GEOTAR Media, 2009. 864 p. [In Russian].

[3] Ulashchik V. S. *Fizioterapiya. Universal'naya meditsinskaya entsiklopediya* [Physiotherapy: a universal medical encyclopedia]. Minsk.: Knizhnyy Dom, 2008. 640 p. [In Russian].

[4] Weiss L. D. (Ed.), Weiss J. M., Pobre T. Oxford American Handbook of Physical Medicine and Rehabilitation. *Oxford University Press*, 2010. 450 p.

[5] Syvolap V. D., Kalens'kiy V. Kh. *Fizioterapiya: pidruchnyk dlya studentiv Vyshchykh medychnyy Navchal'nykh Zakladiv* [PHYSIOTHERAPY Textbook for students of higher medical educational institutions]. Z .: ZDMU, 2014. 196 p.

[6] Yanenko A. F., Peregudov S. N., Fedotova I. V., Golovchanska O. D. (2014). Eguipment and technologies of low intensity millimeter therapy. *Visnyk NTUU KPI Seriia - Radiotekhnika Radioaparatobuduvannia*, Vol. 59, pp. 103-110. doi: 10.20535/RADAP.2014.59.103-110.

[7] Rojas J. C., Gonzalez-Lima F. (2011). Low-level light therapy of the eye and brain. *Eye Brain*, Iss. 3, pp. 49-67. doi: 10.2147/EB.S21391.

[8] Yanenko O., Shevchenko K., Malanchuk V., Golovchanska O. (2019). Microwave Evaluation of Electromagnetic Compatibility of Dielectric Remedial and Therapeutic Materials with Human Body. *International Journal of Biomedical Materials Research*, Vol. 7, Iss. 1, pp. 37–43. DOI:10.11648/j.ijbmr.20190701.15.

[9] Bandara P., Carpenter D. O. (2018). Planetary electromagnetic pollution: it is time to assess its impact. *The Lancet Planeary Health*, Vol. 2, Iss. 12, pp. 512-514. doi:10.1016/S2542-5196(18)30221-3.

[10] Russell C. L. (2018). 5G wireless telecommunications expansion: Public health and environmental implications. *Environmental Research*, Vol. 165, pp. 484–495. doi:10.1016/j.envres.2018.01.016.

[11] Bhatt, C. R., Redmayne, M., Abramson, M. J. et al. (2016). Instruments to assess and measure personal and environmental radiofrequency-electromagnetic field exposures. *Australasian Physical & Engineering Sciences in Medicine*, Iss. 39, pp. 29–42. DOI: 10.1007/s13246-015-0412-z.

[12] Gajšek, P., Ravazzani, P., Wiart, J., Grellier, J., Samaras, T., Thuróczy, G. (2015). Electromagnetic Field Exposure Assessment in Europe Radiofrequency fields (10 MHz–6 GHz). *Journal of Exposure Science & Environmental Epidemiology*, Iss. 25(1), pp. 37-44. DOI: 10.1038/jes.2013.40

[13] *Mezhotraslevaya Internet-sistema poiska i sinteza fizicheskikh princzipov dejstviya preobrazovatelej e'nergii* [Interindustry Internet-based system for searching and synthesizing the physical principles of operation of energy converters]. [In Russian].

[14] Stepanov B. I. *Osnovy spektroskopii otritsatel'nykh svetovykh potokov* [Fundamentals of Negative Light Flux Spectroscopy]. Minsk.: Iz-vo Beluniversit, 1961. 124 p. [In Russian].

[15] Yanenko O. P., Bundyuk L. S., Ponezha H. V. et al. Sposib mikrokhvyl'ovoyi terapiyi [METHOD OF MICROWAVE THERAPY]. *Patent Ukrayiny*, No. 59399, Byul. № 9, 2003.

[16] Koriczkij Yu. V., eds. *Spravochnik po elektrotekhnicheskim materialam: v 3 tomakh, Tom 1* [Reference book on electrical materials. In three volumes. Volume 1]. Moskow, Energoatomizdat, 1986. 368 p. [In Russian].

Особливості низькоінтенсивного енергетичного балансу в процесі фізіотерапевтичного застосування сумішей природних матеріалів

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Авторами досліджені особливості енергетичного балансу, що виникають в процесі використання природних матеріалів в фізіотерапевтичних теплових процедурах. Такі речовини, як озокерит, парафін, нафталан, лікувальні грязі та їх поєднання широко застосовуються в фізіотерапії, тому важливо знати не тільки параметри теплообміну, а також розподіл інших видів енергії, який може впливати на показники ефективності лікувального процесу. Авторами теоретично обґрунтовано і експериментально доказано наявність в спектрі випромінювання озокеритного аплікатора мікрохвильової компоненти. Рівень випромінювання в міліметровому діапазоні аплікатора розміром 10×10 см співставлений з рівнем низькоінтенсивних сигналів технічних засобів для міліметрової терапії. Досліджено динамічну зміну рівня випромінювання мікрохвильової компоненти в процесі охолодження аплікатора від максимальної температури 50°C до температури людського тіла. Виявлено наявність зміни знаку рівня міліметрової компоненти по відношенню до тіла людини, що призводить до формування позитивного і від'ємного низькоінтенсивних потоків мікрохвильового випромінювання. Досліджено діапазони наявності цих потоків та їх рівень. Встановлено, що зміною відсотковим складом парафіну в озокериті можна регулювати рівень і діапазон від'ємних мікрохвильових потоків. Наведені результати попередніх досліджень авторів, які обґрунтовують позитивний вплив від'ємних потоків в тому числі і озокерито-парафінової терапії при запальних процесах з «надлишком енергії» та інших захворюваннях. Досліджене авторами мікрохвильове електромагнітне випромінювання є супутнім фактором під час відповідних фізіотерапевтичних процедур, зокрема теплолікування. Однак цей фактор може суттєво впливати на функціональний стан організму людини, тому його необхідно враховувати при проведенні фізіотерапевтичних процедур.

Ключові слова: мікрохвильове випромінення; від'ємні та позитивні потоки; фізіотерапевтичні процедури; озокерито-парафінова суміш

Особенности низкоинтенсивного энергетического баланса в процессе физиотерапевтического применения смесей натуральных материалов

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Авторами исследованы особенности энергетического баланса, возникающие в процессе использования природных материалов в физиотерапевтических тепловых процедурах. Такие вещества, как озокерит, парафин, нафталан, лечебные грязи и их сочетания широко применяются в физиотерапии, поэтому важно знать не только параметры теплообмена, а также распределение других видов энергии, которое может влиять на показатели эффективности лечебного процесса. Авторами теоретически обосновано и экспериментально доказано наличие в спектре излучения озокеритного аппликатора микроволновой компоненты. Уровень излучения в миллиметровом диапазоне аппликатора размером 10×10 см сопоставим с уровнем низкоинтенсивных сигналов технических средств для миллиметровой терапии. Исследовано динамическое изменение уровня излучения микроволновой компоненты в процессе охлаждения аппликатора от максимальной температуры 50°C до температуры человеческого тела. Выявлено наличие изменения знака уровня миллиметровой компоненты по отношению к телу человека, что приводит к формированию положительного и отрицательного низкоинтенсивных потоков микроволнового излучения. Исследованы диапазоны этих потоков и их уровень. Установлено, что изменением процентного состава парафина в озокерите можно регулировать уровень и диапазон отрицательных микроволновых потоков. Приведены результаты предыдущих исследований авторов, обосновывающих положительное влияние отрицательных потоков, в том числе и озокерито-парафиновой терапии, при воспалительных процессах с «избытком энергии» и других заболеваниях. Исследованное авторами микроволновое электромагнитное излучение является сопутствующим фактором при соответствующих физиотерапевтических процедурах, в частности теплолечении. Однако этот фактор может существенно влиять на функциональное состояние организма человека, поэтому его необходимо учитывать при проведении физиотерапевтических процедур.

Ключевые слова: микроволновое излучение; отрицательные и положительные потоки; физиотерапевтические процедуры; озокерито-парафиновая смесь