UDC 537.877

N.V. Glukhova[1], L.A. Pesotskaya[2], N.G. Kuchuk[3], J.N. Kharlamova[1]

[1] *State Higher Educational Institution "National Mining University", Dnipropetrovsk*
[2] *State Establishment «Dnipropetrovsk medical academy of Health Ministry of Ukraine»*
[3] *V.N. Karazin Kharkiv National University, Kharkiv*

APPLICATION OF WAVELETS TRANSFORM FOR ANALYSIS OF IMAGES OF GAS-DISCHARGE RADIATION OF WATER

The issues of experimental methods of studying biological water properties are considered. The existing problems of theoretical and experimental studies of water properties are described, the key value of features of the structure of water for normal functioning of living organisms is shown. Since the standard classical methods of physical and chemical analysis do not provide the possibility of implementing experimental evaluation of specific biological properties of water, as an alternative, there is proposed a method of recording gas discharge irradiance of liquid-phase objects in an electromagnetic field followed by software image processing based on wavelet analysis. The efficiency of the proposed method was tested on real data samples for distilled water samples and natural water. The results obtained from the extraction of specific parameters of structural features of gas discharge radiance images demonstrate the effectiveness of wavelet analysis algorithms for images of radiation of water samples with different biological properties.

Keywords: *gas discharge radiation, digital image processing, wavelet analysis.*

Introduction

Modern scientific achievements in the field of theoretical and experimental studies of the properties of water as a part of interdisciplinary research emphasize the importance of the analysis of its characteristics, which are vital for the normal functioning of life forms. As organisms contain 70-90% of water, the quality of potable waters has direct influence on the metabolic processes in living cells.

Due to the interdisciplinary research of recent years there has been determined the fact that the existing electrostatic models of water prove that some experimental results of studying the properties of water are inadequate [1]. Besides it is known that water has a few score of anomalous properties which are not consistent with the classical physical-chemical models of its liquid state. Thereby, it becomes apparent that the real nature of water and its properties are beyond the simple chemical formula H_2O.

From the standpoint of influence of the state of water on the metabolism processes of living organisms, recent theoretical and experimental studies have established a close interrelation between the biological and the quantum properties of water. These studies have built a strong platform for further research of the issue of drinking water quality.

One promising area is development of research of quantum properties of water, based on [2]. In some cases, for the molecular level description of structure and dynamics of the liquid phase of water it is enough to apply approach based on the use of classical mechanics. At the same time, a more accurate and complete description is possible only on the basis of quantum-mechanical models [3].

Recent studies show that nuclear quantum effects have a significant impact on the changes in the structure of liquid water and the dynamics of hydrogen bonds. In [4] is emphasized that currently there are no simulation models of liquid water which provide an accurate description of the electronic structure, taking into account the interaction between the nuclear and electronic quantum effects.

The authors of [5] set forth the results of modelling particularly quantum effects and draw a conclusion about the importance of balance of quantum processes in the process of ensuring certain properties of water necessary for the existence of living organisms. Distance variations between the water molecules can weaken the strength of the hydrogen bonds. In its turn, quantum distance variations between atoms and the changes of the bond angle lead to dynamics of biological properties of water.

In [6] a group of physicists offered and studied the model of "competing quantum effects." Competing quantum effects are analyzed on the basis of the study of two different forms of isotopes of water:

1) hydrogen, with one proton;
2) deuterium.

Additional mass of deuterium conditions its decreased reactivity in comparison with hydrogen due to quantum uncertainty in the bond lengths. In other words the bond of deuterium-oxygen is shorter than the bond of hydrogen and oxygen. Experimental studies conducted by scientists, included a beam propagation of electrons in water and further registration of their dispersion. The results confirmed the expressed theoretical hypotheses.

Biological properties of water are caused by interaction forces in the middle of the molecule and intermolecular bonds. In particular, these factors are taken into account by methods of quantum mechanics. The research team in the laboratory Rutherford Appleton Lab (Great Britain) has focused on the study of the quantum properties of water in carbon nanotubes [7]. Specific nature of the experiment consisted in measuring the parameters of the aquatic environment that was limited in the space of small dimensions. As a part of experimental studies of the properties of water placed in carbon nanotubes at room temperature, a substantial difference was found between the recorded measurement data and expected values according to the classical electrostatic model of water. It is found that the protons in the nanoscale aquatic environment have fundamentally different properties than in larger water volumes. On the basis of experimental studies, scientists have concluded that in order to describe the properties of water in space with nanoscale, a completely different approach is needed. Additionally, a hypothesis about the existence of quantum coherence propagated through an electronic network is put forward [8].

It should be noted that UK physics chose particularly carbon nanotubes to implement the research, as they are analogous to the existence of water in the cells of organisms, such as ion channels in cell membranes. As water is an integral part of living organisms, it is involved in all processes of self-organization and renewal. During the interaction of the water and biomolecules the structure of water changes, which leads to the dynamics of its physical properties and change of electromagnetic activity [9]. Under the influence of various external factors, including the biological processes, water changes its state. In [9] it is emphasized that the signals radiated by water in a particular coherent state can be detected and registered.

Study of interrelation of biological and quantum properties of water is a priority area for the Ukrainian Institute of Human Ecology [10, 11]. Timeliness and importance of the study of quantum effects in drinking water is conditioned by the influence of structural change of water on the vital activity of organisms.

In the study the liquid water phase from the point of view of quantum electrodynamics it is proved that the composition of water has specific areas with the presence of coherent domains [12, 13]. The specific size of coherent domain is caused by the wavelength of the quantum transition from the ground state to the excited state. Energy-wise, ground and excited states are different. The value of the difference in energies is directly related to the wavelength of soft X-ray photon. It is necessary to consider that each domain is surrounded by a field that exists beyond its borders. Bonds between the individual domains are set particularly because of the existence of adjacent fields, as if "bonding together" the individual domains in the conglomerates.

For distilled water it is characteristic that coherent domains are present in its composition, but they do not form mutual coherence between them. The lack of mutual coherence does not allow distilled water to essentially react to external influence.

On the basis of studying the clustering model of liquid water, it is found that the formation of coherent areas in water structure significantly improves the biological properties of drinking water. Special studies confirmed the fact that consuming water in a coherent state by human improves connectivity in a fractal state of biological fluids and restores the physiological functions of the body as a whole and the cardiovascular system, in particular [14-16].

Materials and methods. The established interrelation between biological and quantum properties of water [17] in choosing and developing experimental methods of researching drinking water state requires such physical substantiation of the used principles of measurement as to be able to provide the registration of the effects of intermolecular interactions in the structure of water including the manifestations of specific properties of domains in a coherent state.

According to the research results presented in [18], the formation of bio photons is provided by the existence of coherent domains of water. To illustrate the properties of water in a coherent state the author [18] has described the example of lightning formation. From the perspective of modern concepts of quantum electrodynamics, extracted electrons from the water are the source of powerful charge contained in the lightning. Drops of water are the only source of electrons, and the water is in a coherent state, as only such state provides discharge by the free charge carriers. Similarly, the coherent domains act as an electron donor during the redox reactions in the cells of living organisms.

Physical processes like the formation of lightning in the atmosphere occur during the formation of the gas discharge in experimental studies based on the image registration of gas-discharge radiation of liquid-phase objects [19-22]. Evaluation of biological properties of water in this paper is based on the measurement method consisting in fixing the gas discharge glow on photomaterial structure in the electromagnetic field around the test sample of water and in the area of its contact with the X-ray film. Physical effects arising from the registration of gas-discharge radiance of liquid phase object placed in an electromagnetic field of high tension are conditioned by the ionization of the molecules of the gas medium between the electrodes by means of electrons and photons simulated with electronically excited complex molecular structures of water.

Experimental researches are implemented using the «РЕК-1» recorder. The device is intended for visualization of gas-discharge radiance of biological or physical objects on the photosensitive material and X-ray film [23]. Structurally, the recorder is designed as a desktop device. Control board with radioelements, switching arrangements and signalling system are positioned in the housing stand. On the cap of the recorder, working electrode of foil-clad paper-based laminate is set. Above the working electrode a guide conductor is set. The work of PEK-1 recorder is based on impact excitation of a circuit consisting of the inductance of the secondary winding of the matching circuit and the load capacitance connected to it. The generated excitation pulses provide a flow of electric current through the buffer resistor, working electrode, circuit with the object of research and passive electrode.

The recorder of gas-discharge radiance includes a flat high-voltage electrode which has a photographic material (X-ray film), a crib that is connected to the flat electrode and a current source, a measuring container with a rod for receiving the test liquid, a hollow needle of electrically conductive material to generate a non-uniform electric field. The crib is mounted above the surface of the photographic material at a height at which there is provided a gap between the surface of the photographic material and the needle placed in a hollow metal tube of the center hole of crib, wherein the outer diameter of the needle corresponds to the inner diameter of the tube for creating a non-uniform electric field.

The sequence of imaging the gas-discharge radiance of liquid phase object is as follows. On the working surface of a flat electrode is placed a photographic material over which a crib is set. The test liquid of specified volume is poured into measuring container – the needle that is placed in a hollow tube. Forcing the rod of measuring container down, the test liquid of specified volume flows onto photographic material, creating a droplet whose surface is in contact with the needle. Voltage is applied between the flat electrode and the electrode for generating an electric field, whereby the gas discharge occurs between the electrodes. After exposure, the photographic material is subjected to the established chemical treatment, and one gets an image of the structure of the gas discharge irradiation around and in the contact area of the liquid with photographic materials.

When water is exposed to external electric field, features of the generation of gas discharge around the sample are noted. Water condition can be identified by their characteristic features. For example, thanks to research in the field of quantum electrodynamics it has been established [18] that the so-called "normal", distilled water, stays in an incoherent state. This means that the domains in its structure do not form joint coherence manifesting itself in constructing bonds between domains in the form of synthesis of conglomerates or confederation of domains. In incoherent state, liquid water molecules are unable to act as reducing agents, i.e. as electron donors. Incoherent water keeps electrons so strongly that it can be regarded as a mild oxidant. Such fundamental changes of water significantly influence on the metabolism of living cells, and, therefore, are subject to detailed analysis.

Water in a coherent state is a good reducing agent - an electron donor, which is a prerequisite of formation of bio photons. The energy of the excited state of the coherent domain approaches to the ionization energy of water molecules. Thus, in the coherent state, water donates electrons easily because the coherent domains are surrounded by clouds of quasi-free electrons. To excite this electron plasma, small portion of energy that does not exceed 0.2 eV is sufficient [18].

Thus, making a comparative analysis of the physical processes occurring in biochemical reactions of organism and in forming of lightning in the atmosphere, it can be assumed that process characteristics of the formation of gas discharges during the registration of image of gas discharge radiance of liquid-phase objects in an electric field are in the correlation dependence with biological and quantum properties of liquid state of water, in particular, by the presence of coherent areas in its structure – being the necessary sources of free charge carriers for all of the above physical and biochemical processes.

Water samples from different sources and, respectively, with different properties was used as materials for the realization of the experimental studies of water properties in the electric field. Samples of "normal" distilled water were selected as a standard for the comparative analysis, because the available theoretical and experimental studies have shown that this type of water stays in an incoherent state.

A brief description of applied approaches. In the qualitative analysis of irradiance image, experts usually take into account the following signs of images of gas-discharge radiance of water: inner ring with radial streamers directed outwards that create middle ring and subtle luminescence, which as a whole gives the characteristic of the width of ambient illumination; irradiation structures in the contact area of the test sample with X-ray film (inner circle of the image) for granular inclusions and obscurations (Fig. 1 and 2a). At the first stage, the proposed estimation method of biological characteristics of water includes the recording of gas-discharge radiance of images of objects in electromagnetic field. At the second stage, in order to parameterize the irradiance structures, digital computer data processing is implemented.

For carrying out the multiresolution study of geometric features of image of discharges propagation, mathematical apparatus of wavelet analysis was chosen. Wavelet analysis of digital images of gas discharge irradiance is applied to the functional dependence, which is the pixel brightness profile along a straight line. For maximum coverage of details of the image - the crowns of irradiance, streamers, the drop inner circle - the brightness profile is plotted from the upper corner of the image f (0,0) to the bottom of f (M-1, N-1), ie, all the pixels located on the diagonal of pixel brightness matrix of halftone bitmap are covered. In the graph of profile brightness (Fig. 1b and 2b) on the horizontal axis is denoted the coordinate of the original digital image, on the vertical axis - the brightness values of pixels along the chosen direction of the profile which are standard coded by integers in the range from 0 to 255.

For detalization in identifying the specific features (patterns) of images of discharge propagation caused by different physical, chemical and biological properties of water samples, the wavelet analysis is used, which provides a multiresolution transformation [24] of input functional dependence. Unlike traditional methods of signal and image processing using the Fourier transform, wavelet analysis in many application areas demonstrates the high informative results, flexibility of algorithms, ability to process and separate subtle features of signals and images that are not available for the detection and identification with classical methods of spectroscopy.

The operation of direct continuous wavelet transform is carried out according to the rule:

$$W_f(a,b) = |a|^{-1/2} \int_{-\infty}^{\infty} f(t)\psi^*\left(\frac{t-b}{a}\right)dt,$$

where a and b – are the parameters that define the scale and offset of functions ψ, respectively; ψ – is the analyzing wavelet; * – is the symbol of complex conjugation; $f(x)$ - is the function under study (input data for transform or analysis); $W_f(a,b)$ – is a set of wavelet coefficients

Thus, the wavelet transform splits data or functions into components with different frequencies, each of which at the following stage can be studied with a different resolution, i.e. scale [24]. The method is based on the fundamental concept of the representation of arbitrary functions on the basis of shifts and scaling of one localized wave (wavelet function).

Solving the problem of digital image processing of gas-discharge radiance, original functions under study f(x) – the brightness profile curve – is discrete, i.e. consists of a bounded sequence of individual brightness values of pixels along a straight line, thus under such character of this original sequence, discrete wavelet transform of the following form is used:

$$W_A(a,b) = \frac{1}{n(a,b)} \sum_{k=0}^{N-1} f_k \psi^*\left(\frac{t_k - b}{a}\right).$$

To analyze the characteristics of the profile curve of brightness, calculation of approximation and detail coefficients of different levels of the wavelet transform functions was used. Coefficients are obtained by the convolution operation of the original sequence with a filter decomposition of low frequencies for approximation (Fig. 1 and 2, c-e), and decomposition filter for high-frequency for detailing (Fig. 1 and 2, d-f). During the decomposition, Haar and Daubechies wavelets are used [25].

Results and discussion

The decomposition of the original sequence of brightness values of pixels in the wavelet transform is used effectively to isolate patterns of images of gas-discharge radiance of liquid-phase objects. When approximating the signal (Fig. 1 and 2, c, e), general changes in the brightness of pixels along the diagonal of the image are available for observation. Parametrization at this stage is possible thanks to quantitative evaluation of width of irradiance corona by analyzing changes the brightness of pixels.

For tap water, rather "sharp" lows in these graphs indicate that the crown is narrow and fuzzy. Localization of the features of digital image of gas-discharge radiance, which is shown as a "branching" irradiance crown, is effectively investigated by increasing the level of detail (Fig. 1 and 2, d, f). For natural water compared with tap water, the growth of both the spatial frequencies and amplitudes of the high-frequency component of the function that describes the changes in brightness along the chosen picture profile is characteristic.

Fig. 3 shows images of gas-discharge radiance and the corresponding results of wavelet analysis for distilled water; this type of water from the point of view of quantum electrodynamics is defined as an environment in an incoherent state and is characterized by unfavorable biological properties for living systems.

The main feature of the water in the incoherent state is the lack of free or quasi-free charge carriers. This property makes it impossible to maintain normal conditions for the implementation of redox reactions in the cells of living beings.

Detalization of the dynamics of change of image pixels brightness as a function of spatial coordinate is clearly tracked using wavelet analysis (Fig. 1-3, d-f). For distilled water the maximum amplitude of brightness on the graphs detailing the coefficients according to the Haar basis do not exceed the absolute value of 5, by the decomposition based on Daubechies basis the maximum value is 7, but the vast majority of the pulse-spike amplitudes is within the range of ± 1.

After exposing the water sample in an incoherent state of the external electromagnetic field, one can observe a qualitatively different image of registration of gas-discharge radiance under the lack of free charge carriers required for the flow of electric current between the electrodes.

In particular, it is manifested through the feeble corona of irradiance, which consists of individual streamers of spread of local discharges on the touch-sensitive surface of the photographic material.

For tap water amplitude spikes in the graph of decomposition according to the Haar basis (Fig. 1d) are within 10, according Daubechies basis (Fig. 1, f) they are respectively in the range of ± 5. F

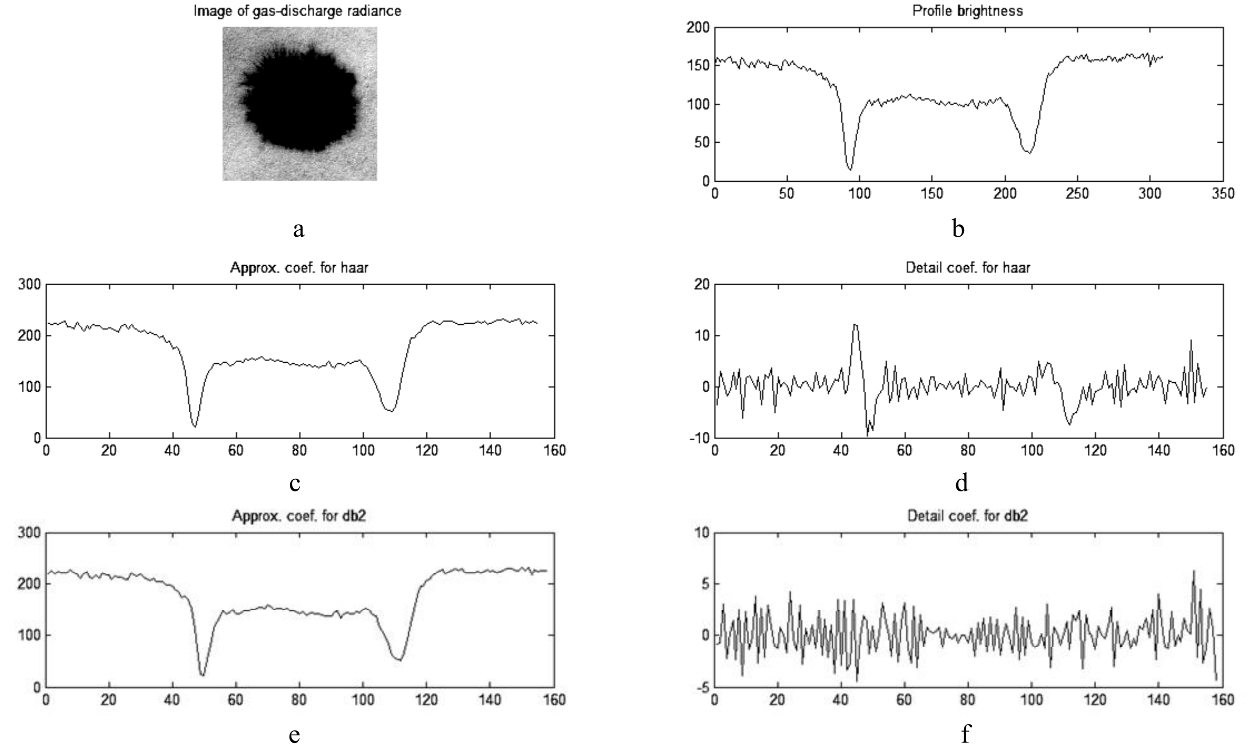

Fig. 1. Wavelet analysis of the brightness profile of the gas-discharge radiance of tap water sample: a – the original image of gas-discharge radiance; b – the brightness profile; c, d – wavelet decomposition based on Haar wavelet; e, f – wavelet decomposition based on Daubechies wavelet

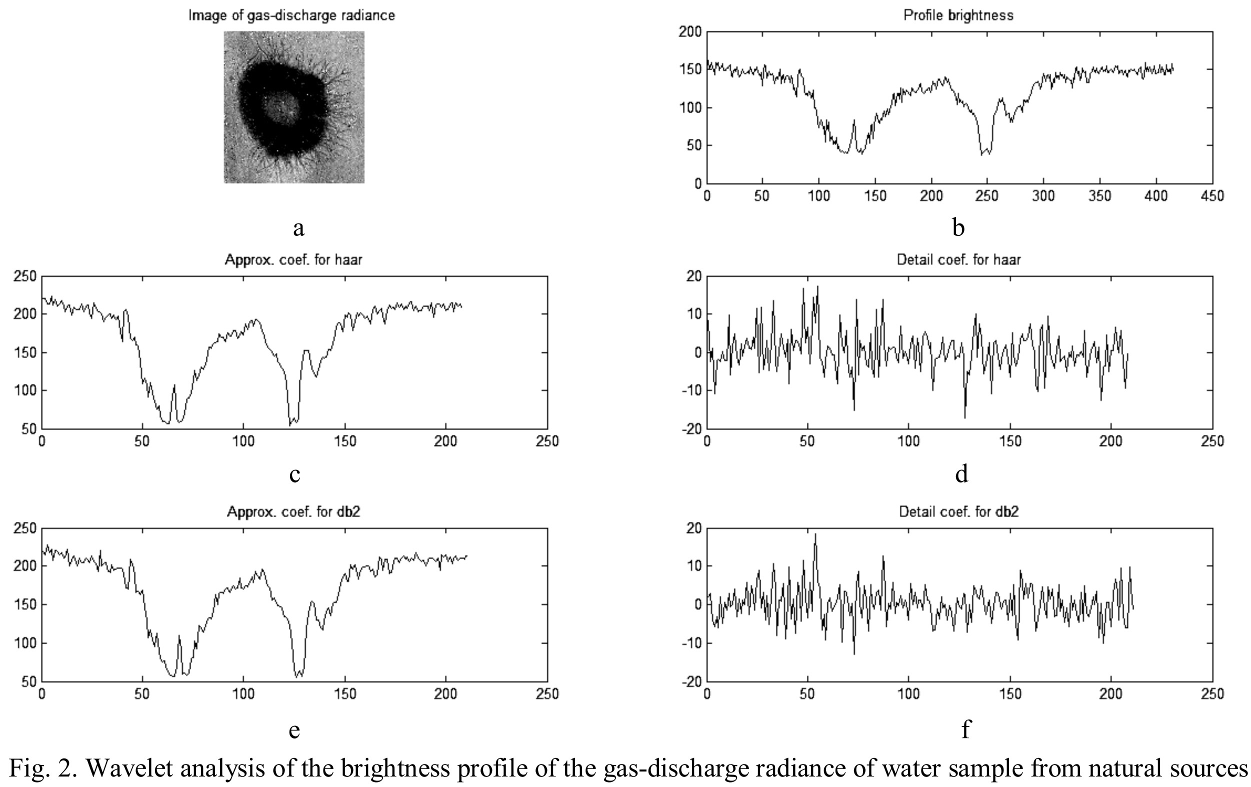

Fig. 2. Wavelet analysis of the brightness profile of the gas-discharge radiance of water sample from natural sources "Sofiyivka": a – the original image of gas-discharge radiance; b – the brightness profile; c, d – wavelet decomposition based on Haar wavelet; e, f – wavelet decomposition based on Daubechies wavelet

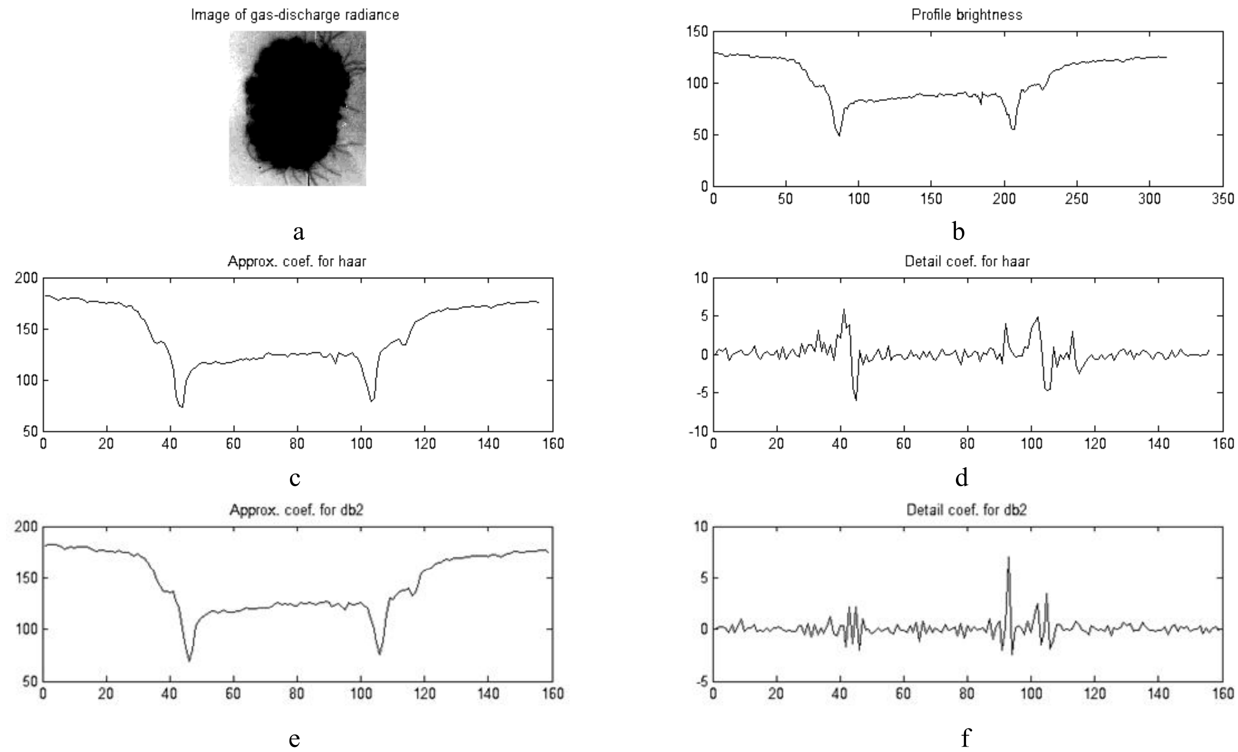

Fig. 3. Wavelet analysis of the brightness profile of the gas-discharge radiance of distilled water sample: a – the original image of gas-discharge radiance; b - the brightness profile; c, d – wavelet decomposition based on Haar wavelet; e, f – wavelet decomposition based on Daubechies wavelet

For water from a natural source, which is in a coherent state and has good biological properties, the corresponding figures of irradiance brightness in the propagation of streamers of gas discharge are as follows: for detailing coefficients according to the Haar basis (Fig. 2d), the amplitude range is ± 20, in the basis of Daubechies (Fig. 2f), respectively, the monitored amplitudes are within the range of ± 20.

Conclusion

The estimation method of the biological properties of water is proposed based on recording and digital image processing of gas-discharge radiance of liquid-phase objects in an electromagnetic field. For quantitative assessment of specific characteristics of irradiance images recorded on the X-ray film, it is proposed to use the parameterization images based on multiresolution wavelet analysis.

Wavelet analysis ensures singling out components of different scales from the profile curve of pixel brightness so that each element can be analyzed with the degree of detail that matches its scale. Because of these properties of the selected mathematical apparatus of spectroscopy the accuracy of the image analysis of gas-discharge radiance of liquid-phase objects is increased, while the role of subjective deposits with expert analysis is reduced.

The developed method provides not only an assessment of biological properties of water on a qualitative level, but also implements the establishment of a quantitative interrelation between the calculated coefficients of wavelet decomposition and biological indicators of water quality.

References

1. Markland, Thomas E., Berne, B.J. (2012). Unraveling quantum mechanical effects in water using isotopic fractionation. Proc Natl. Acad. Sci. USA, 109(21), 7988-7991.

2. Kuharski, R.A., Rossky, P.J. (1984). Quantum mechanical contributions to the structure of liquid water. Chem Phys Lett., 103, 357–362.

3. Jens Aage Poulsen, Gunnar Nyman, Peter J. Rossky. (2005). Static and dynamic quantum effects in molecular liquids: A linearized path integral description of water. Proceedings of the National Academy of Sciences of the USA (PNAS), 102(19), 6709–6714.

4. Wang, L., Ceriotti, M., Markland, T. E. (2014). Quantum fluctuations and isotope effects in ab initio descriptions of water. Chem. Phys., 141, 104502.

5. Habershon, S, Thomas, E. Markland, D. E. (2009). Competing Quantum Effects in the Dynamics of a Flexible Water Molecule. The Journal of Chemical Physics, 131 (2), 234–241.

6. Zeidler, A. (2011). Oxygen as a Site Specific Probe of the Structure of Water and Oxide. Materials. Physical Review Letters, http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.107.145501, (2015 April).

7. Reiter, G. F., Aniruddha, D. Y. Sakurai, I. M., Krishnan, V. G., Paddison, S. J. (2013). Anomalous Ground State of the Electrons in Nanoconfined Water. Physical review letters, 111 (3), http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.111.036803, (2015 April).

8. Mayers, J., Reiter, G. (2012). Spurious indications of energetic consequences of decoherence at short times for scattering from open quantum systems. AIP Advances, 2 (3), *032137. http://scitation.aip.org/content/aip/journal/adva/2/3/ 10.1063/1.4746093, (2015 April).*

9. Tedeschi, A. On the coherent water's edge. Conference on the Physics, Chemistry and Biology of Water. http://www.waterconf.org/participants-materials/abstracts/Tedeschi.docx. (April 2015).

10. Kuryk, M. V., Pisotska, L. A, Glukhova, N. V., Horova, A. I., Borysovska, O. A., Pavlishyn, A. V. (2013). Kirlian graphical estimation of bioavailability of substances. Medical informatics and engineering, 2, 37–41.

11. Krasnobryzhev, V. G., Kuryk, M. V. (2010). Quantum effects in natural water. Quantum magic, 7 (4), 4132–4138.

12. Arani, R., Bono, I., Del Giudice, E., Preparata, G. (1995). Qed coherence and the thermodynamics of water. Modern Physics Letters B, 9, 510–532.

13. Bono, I., Emilio Del Giudice, Luca Gamberale, Marc Henry (2012). Emergence of the Coherent Structure of Liquid Water. Water, 4 (4), 510–532.

14. Johannson, B. Do quantum state oscillations in natural drinking water benefit human health? Conference on the Physics, Chemistry and Biology of Water., http://www.waterconf.org/participants-materials, (2015 April).

15.Johannson, B. (2008). Synchronized water and production and use thereof. Patent CA 2691264 A1, Canada.

16. Johansson, B. (2009). Effects of Functional Water on Heart Rate, Heart Rate Variability, and Salivary Immunoglobulin A in Healthy Humans: A Pilot Study. J. Altern. Complement. Med., 15, 871—877.

17. Marco Bischof, Emilio Del Giudice (2013). Communication and the Emergence of Collective Behavior in Living Organisms: A Quantum Approach., Molecular Biology International, 2013, 987549, doi:10.1155/2013/987549.

18. DelGuidice, E. (2014) Coherent quantum-electrodynamic organization of biochemical processes. Journal of forming branches of science., 4(2), 92-99.

19. Korotkov, K., Korotkin, D. (2001) Concentration dependence of gas discharge around drops of inorganic electrolytes. J.Appl. Phys., 89. P. 4732—4737.

20. Korotkov, K., Krizhanovsky, E., Borisova, M. (2004) et al. The Research of the Time Dynamics of the Gas Discharge Around Drops of Liquids. J. Appl. Phys., 95(7), 3334—3338.

21. Glukhova, N. V., Korsun, V.I., Pesotskaja, L.A., (2013). Automation of processing of images of irradiation of liquid-phase objects using flicker-noise spectroscopy. Metrology and tools, 2(40), 59-63.

22. Bologa, A., Paur, H.-R., Seifert, H., Woletz, K. (2011). Influence of Gas Composition, Temperature and Pressure on Corona Discharge Characteristics. International Journal of Plasma Environmental Science & Technology, 5(2), 110-116.

23. Glukhova, N. V., Pisotska, L. A., Horova, A. I. (2014) Method of rapid assessment of the state of the liquid phase object. Patent 86701 (Ukraine).

24. Shakhakarmi, N., (2012). Quantitative Multiscale Analysis using Different Wavelets in 1D Voice Signal and 2D Image. IJCSI International Journal of Computer Science Issues, 9(1), No 2, 475-484.

25. Daubeches, I. (1992). Ten Lectures on Wavelets. Philadelphia. MIAN.

Надійшла до редколегії 29.01.1016

Рецензент: д-р техн. наук, проф. В.І. Корсун, ДВНЗ «Національний гірничий університет», Дніпропетровськ.

ВИКОРИСТАННЯ ВЕЙВЛЕТ-ПЕРЕТВОРЕННЯ ДЛЯ АНАЛІЗУ ЗОБРАЖЕНЬ ГАЗОРОЗРЯДНОГО ВИПРОМІНЮВАННЯ ЗРАЗКІВ ВОДИ

Н.В. Глухова, Л.А. Пісоцька, Н.Г. Кучук, Ю.М. Харламова

Робота присвячена питанням експериментальних методів дослідження біологічних властивостей води. Розглянуто існуючі проблеми теоретичного та експериментального дослідження властивостей води, показано ключове значення особливостей структури води для нормального функціонування живих істот. Оскільки класичні методи фізико-хімічного аналізу не забезпечують можливості реалізації експериментальної оцінки специфічних біологічних властивостей води, то, у якості альтернативного способу, запропонований метод реєстрації зображень газорозрядного випромінювання рідиннофазних об'єктів в електромагнітному полі з подальшою програмною обробкою зображень на основі вейвлет-аналіза. Ефективність запропонованого методу апробовано на реальних вибірках даних для зразків дистильованої, водопровідної та природної води. Отримані результати вилучення специфічних параметрів зі структурних особливостей зображень газорозрядного випромінювання демонструють ефективність алгоритмів вейвлет-аналізу зображень випромінювання зразків води з різними біологічними властивостями.

Ключові слова: *газорозрядне випромінювання, цифрова обробка зображень, вейвлет-аналіз.*

ПРИМЕНЕНИЕ ВЕЙВЛЕТ-ПРЕОБРАЗОВАНИЯ ДЛЯ АНАЛИЗА ИЗОБРАЖЕНИЙ ГАЗОРАЗРЯДНОГО ИЗЛУЧЕНИЯ ОБРАЗЦОВ ВОДЫ

Н.В. Глухова, Л.А. Песоцкая, Н.Г. Кучук, Ю.Н. Харламова

Работа посвящена вопросам экспериментальных методов изучения биологических свойств воды. Рассмотрены существующие проблемы теоретического и экспериментального исследования свойств воды, показано ключевое значение особенностей структуры воды для нормального функционирования живых организмов. Поскольку стандартные классические методы физико-химического анализа не обеспечивают возможности реализации экспериментальной оценки специфических биологических свойств воды, то, в качестве альтернативного способа, предложен метод регистрации изображений газоразрядного свечения жидкофазных объектов в электромагнитном поле с последующей программной обработкой изображений на основе вейвлет-анализа. Эффективность предложенного метода апробирована на реальных выборках данных для образцов дистиллированной, водопроводной и природной вод. Полученные результаты извлечения специфических параметров из структурных особенностей изображений газоразрядного излучения показывают эффективность алгоритмов вейвлет-анализа изображений излучения образцов воды с разными биологическими свойствами.

Ключевые слова: *газоразрядное излучение, цифровая обработка изображений, вейвлет-анализ.*