Registration of Different Types of Water with Corona Gas Discharge Effects and Parameters of Brightness

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Abstract
Corona gas discharge (CGD) is a physical process that occurs when a gas is ionized. It is observed as a bluish glow at high breakdown voltages from 5 to 30 kV. In laboratory conditions, [1] has objectively studied CGD, in the former USSR, in the late 1940s. The method was classified as electrophotography, for recording information. Based on an electrophotographic information recording, Carlson developed xerography in the 1960s. [3] has conducted experiments using electrophotographic CGD methods, to record data. Antonov and co-authors proved that CGD primarily depends on the object's dielectric permeability rather than on conductivity. [15, 16] have measured photon emission in different types of water. The method is called color coronal spectral analysis. Since 2012, [12] have developed a method for analyzing CGD image, assessing brightness for various water types. The authors consider that, with CGD, information is connected with water dielectric permeability and, thus, with H_2O molecules restructuring. The developed method of water classification allows for an integral assessment of H_2O characteristics. The experimental sample was classified based on brightness histogram (BH) analysis of CGD radiation images.

Keywords: BH; CGD; discharge image; H_2O.

Introduction•

In the former USSR, [1] has pioneered a laboratory method for registering CGD, using black-and-white photographic films. In 1975, [2] have described as electrophotography the phenomenon of CGD, and its effect on photographic films. [3] has developed CGD photography method in 1968 [3, 4]. [5, 6] have also contributed to this field in 1968, followed by [7], in 1973, and [8], in 1975. [9], in 1980, [10], in 1982, and [11-13], in 2004 and 2012, have made further advancements. In 2007, [14] has introduced color registration in CGD methods, called Color Coronal Spectral Analysis [15-17]. Additionally, [18] has devised a

• The abbreviation list is on page 225.

plan involving discharge activation, using a 5% NaCl solution in a transparent electrode.

Experimental materials and equipment for the research have included X-ray film and a device with an attachment for liquid-phase objects, developed with the participation of the "L. Shupik National University of Healthcare of Ukraine" (Kyiv) and NTU "Dnipro Polytechnic" (Dnipro, Ukraine) [19]. In 2023, the device for water drops investigation was patented [20].

The recorded two-dimensional images of CGD radiation on X-ray film were converted into a digital format through analog-to-digital conversion. Computer image analysis was used to evaluate the properties of the examined H_2O samples.

The information technology for computer analysis involves algorithms and application software for comparative examination of geometric and photometric image parameters [21-23]. The computer analysis used a previously formed database of images of various types of CGD radiation from H_2O samples. The database is an integral part of computer image analyses with information technology. The database includes, at least, 900 images of CGD radiation for each sample type. This number of images was used to increase the reliability of statistical estimates and provide a rational basis for identifying distribution laws of image histogram parameters.

The integral assessment of an image is its histogram, for which modern image processing software applications have standardized brightness range values. For grayscale digital images, the adopted value of histogram columns is identical to the number of gray tone gradations, which is 256. Images of CGD radiation for different types of H_2O, and their corresponding BH, are presented in Figs. 2-5.

Information technology was developed to optimize computational procedures and accommodate expert assessments in the algorithm. It is based on the construction, subsequent analysis, classification, and fuzzy clustering algorithms (which this work has not used) of images based on their BH (comprising 12 columns). The rationale for choosing this specific number of intervals, the optimization perspective of computational procedures and metrological requirements for the justified selection of the number of histogram intervals were outlined from [12].

In experimental studies of liquid properties using electroradiation technologies, the external influence of pulsed electromagnetic fields is applied to the examined fluid sample. The dynamic processes that arise during this experiments involve several physical mechanisms during which CGD radiation occurs.

The study of H_2O properties using this method is based on a cause-and-effect relationship driven by the physical effects of optical emission that directly arises from the liquid sample surface. An external energy source - a pulsed voltage generator - is required to initiate the CGD process. Due to the formation of a pulsed electromagnetic field between the electrodes, the gas gap and the liquid surface, CGD arises. The pulsed voltage generator ensures the presence of an electromagnetic field intensity that is sufficient for gas breakdown with subsequent transition to an ionized state. Analytically, the physical processes occurring during CGD radiation can be described using dependencies for electromagnetic field distribution present in a cylindrical coordinate system [24].

$$rot\,\vec{E} = -i\omega\mu_a \vec{H},$$

$$rot\,\vec{H} = \frac{1}{-i\omega\varepsilon_a}\left(\frac{\partial^2 \vec{E}_\rho}{\partial\rho^2} + \frac{\partial^2 \vec{E}_\varphi}{\partial\varphi^2} + \frac{\partial^2 \vec{E}_z}{\partial z^2}\right) = \frac{1}{-i\omega\varepsilon_a}\Delta\vec{E},$$

where H and E are magnetic and electric field intensity, respectively; i is magnetic permeability of the object; ω is angular frequency; ε and μ are absolute and relative electric permittivity of the studied object, respectively; and index $_\alpha$ in ε_α is an absolute parameter in a cylindrical coordinate system. Parameters in the cylindrical coordinate system are as follows: ρ index is radius, φ is azimuth angle, z is height and Δ is Laplas operator.
Herein, research on control and experimental liquid samples was conducted based on the application of electroradiation technologies. Distilled H_2O was chosen as the control sample. The research aimed to assess three types of water from Bulgaria. Based on their physicochemical composition and geological characteristics, they were defined as tap, mountain spring and drinking waters. The categorization was done using a method for CGD radiation brightness developed by [12].

Methods and materials

Parameters of the device for CGD

Fig. 1 illustrates the device for researching CGD with H_2O drops [20].

Figure 1: Device for researching CGD with H_2O drops.

The parameters of the device for registering CGD on an X-ray film are presented in Table 1.

Table 1: Instrument parameters for registration.

Parameter (measurement unit)	Value
Amplitude of the exposure pulse (kV)	3.0-5.0
Pulse duration (μs)	5.0-10.0
Number of exposure pulses	1-10
Size of exposure electrode (working part of the device)	90±0.5
Time of continuous work (h)	8.0
Battery supply voltage	3 V
Average earnings per refusal, photographing cycles	25100
Overall dimensions of the device (mm)	150 x 200
Frequency	12 kHz

Physical parameters

The developed information methodology was based on calculating median values. It involved calculating medians for 12 histogram columns and differences between them in adjacent brightness intervals. The distribution law of brightness in samples of CGD radiation images does not correspond to the standard Gaussian distribution model. Therefore, to compute average brightness pixel values within certain division intervals, median values were estimated, rather than arithmetic means:

$$Med_n = \frac{1}{2}\left(x_{n/2} + x_{n/2+1}\right)$$

for an even number of images in sample n.

$$Med_n = x_{\frac{(n+1)}{2}}$$

for an odd number of images in sample n, where x_i is the element in the experimental data sample.

Results

CGD images and BH of different types of water

A water probe was performed in ten images. BH is widely used in image processing and analysis [23]. X-axis represents brightness data, with gradations from black to white. Y-axis represents the count of pixels of a certain brightness. BH of distilled H_2O, as shown in Fig. 2, corresponds to a sample with an electrical conductivity of 3.13 µS/cm^{-1} [25].

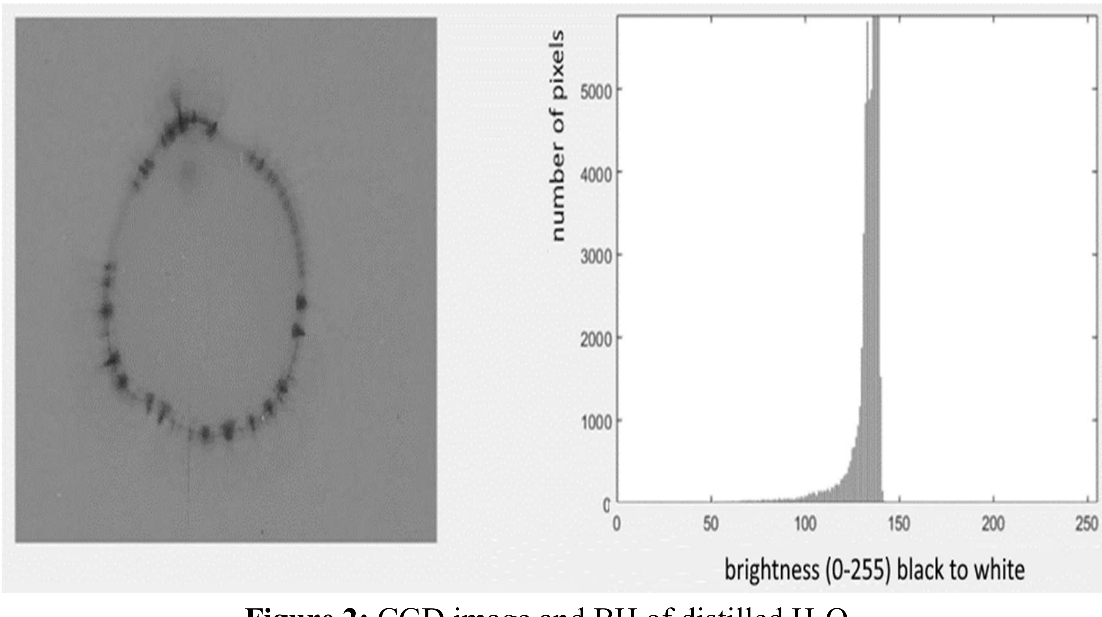

Figure 2: CGD image and BH of distilled H_2O.

In July 2023, studies were conducted on three types of water from Bulgaria. These included tap, mountain spring and drinking waters from Varna (ASL 80 m), Dryanovski Monastery (ASL 320 m) and Madara village (ASL 203 m), respectively.

Fig. 3 illustrates a CGD image and BH of tap water.

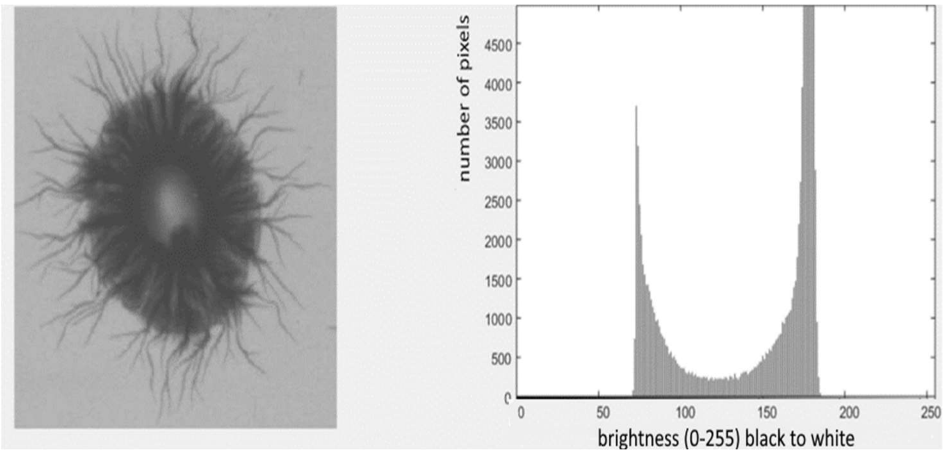

Figure 3: CGD image and BH of tap water.

Fig. 4 shows a CGD image and BH with mountain spring water.

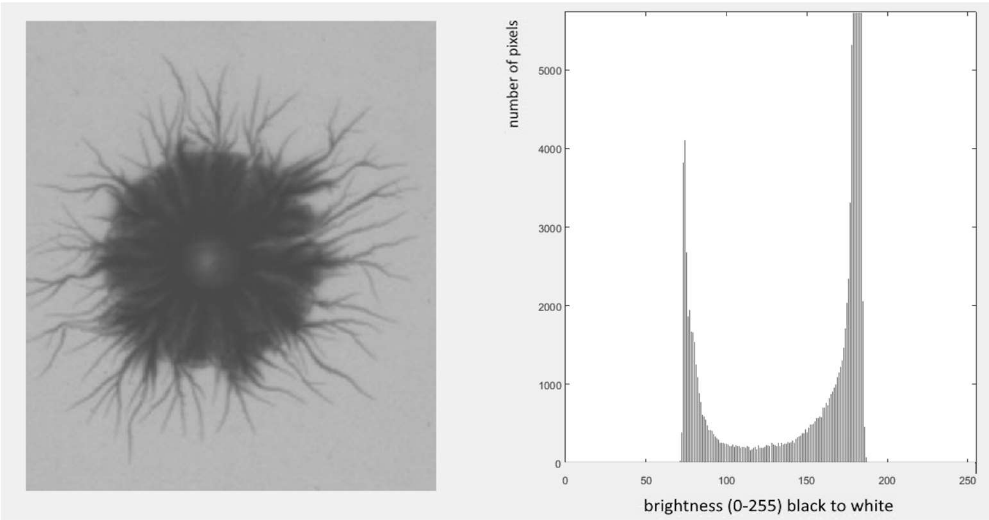

Figure 4: CGD image and BH with mountain spring water.

Fig. 5 shows CGD and BH images of drinking water.

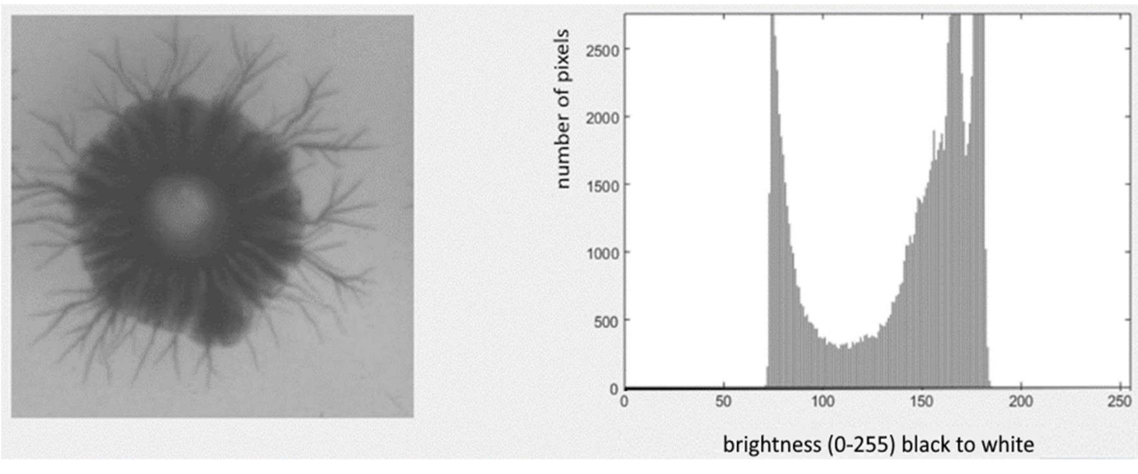

Figure 5: CGD image and BH of mountain spring water.

Results for medians from the brightness of different types of water

The median values indicate the number of pixels within a specific brightness interval. Table 2 illustrates the results of medians for tap water.

Table 2: Results of medians for tap water.

Brightness interval number	X axis values from 0 to 255	Values of medians	Differences between medians	Ratio of differences
1	0-20	0	0	-
2	21-41	0	2	-
3	42-62	2	2413	1206.5
4	63-83	2415	3942	1.63
5	84-104	6357	1005	0.25
6	105-125	7362	7932	7.89
7	126-146	15294	-13133	-1.65
8	147-167	2161	34	-0.01
9	168-188	2195	1604	47.18
10	189-209	3799	8476	5.28
11	210-230	12275	-12270	-
12	231-255	5	0	-

Table 3 illustrates the results of medians for mountain spring water.

Table 3: Results of medians for mountain spring water.

Brightness interval number	X axis values from 0 to 255	Values of medians	Differences between medians	Ratio of differences
1	0-20	0	0	
2	21-41	0	0	
3	42-62	0	1900	12.13
4	63-83	1900	23054	-0.80
5	84-104	24954	-18445	0.11
6	105-125	6509	-1966	-0.12
7	126-146	4543	213	16.82
8	147-167	4756	3583	4.95
9	168-188	8339	17733	1.96
10	189-209	26072	34777	-1.75
11	210-230	60849	-60849	
12	231-255	0		

Table 4 illustrates the results of medians for drinking water.

Table 4: Medians for drinking water.

Brightness interval number	X axis values from 0 to 255	Values of medians	Differences between medians	Ratio of differences
1	0-20	0	0	0
2	21-41	0	0	0
3	42-62	0	0	0
4	63-83	0	23146	-0.61
5	84-104	23146	-14073	0.28
6	105-125	9073	-3923	-0.39
7	126-146	5150	1526	5.21
8	147-167	6676	7943	2.28
9	168-188	14619	18084	0.91
10	189-209	32703	16506	-2.98
11	210-230	49209	-49209	0
12	231-255	0	0	0

Conclusion

CGD was generated under laboratory conditions. Using the parameters specified in the methods, waters from Bulgaria were investigated. Tap, mountain spring and drinking waters were studied. BH were created using a method developed by [12], in 2012. The research involved applying BH to assess different H_2O types using CGD. The images for the analyses were black and white. The results correspond to H_2O qualification: tap water, from Varna; natural water, from Dryanovski Monastery; and functional water, from Madara village, which is famous in Bulgaria for its healing properties.

Authors' contributions

Ignat Ignatov, **Ludmila Pesotskaya**, **Natalia Glukhova**, **Natalia Yevdokimenko**: conceived the original idea of the analysis and research paper; collected data; performed experimental work, inserted data or analysis tools; wrote the paper. **Ludmila Pesotskaya**, **Natalia Glukhova**: analyzed data obtained by experiments. **Teodora P. Popova**, **Alexander I. Ignatov**, **Chavdar Stoyanov**: collected data; performed experimental work; wrote references.

Abbreviations

ASL: above sea level
BH: brightness histogram
CGD: corona gas discharge
H_2O: water
USSR: Union of Soviet Socialist Republics

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