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SPECTROPHOTOMETRIC SYSTEM OF THE WATER RESOURCE'S CONTROL AND LOCATION

Abstract

The developed optical control-and-measuring system is for the ecological monitoring of the water bodies with the scattering indicatrix method (bodies of the brightness). Water-dispersed measurement procedure was analyzed. This measurement procedure permits system to determine parameters of the particle pollution of the different origin for the demands of the ecological monitoring.

The condition of the ecological parameters of the water bodies can be determined according to their characteristics. Water is the dispersion from the optical viewpoint. Nowadays optical methods are the most spread estimation methods of the dispersed particle's concentration, size, shape and structure. It is declared by the ease and express of the mentioned methods, their data precision and the visualization of the obtained results.

For the determination of the presence and object's form in the analyzed medium it is necessary to know data about the reduction factor ε' of the limit scattered radiation, spatial raying of the dispersion's medium extent E_0, descending $E_{\downarrow}$ and ascending $E_{\uparrow}$ currents within and at the border of the layer. So the abyssal (deep-laid) regime is an asymptotic photonic regime on the definite depth, when the optical characteristics become stationary and are stipulated by the medium's nature and are independent from conditions and the illumination's origin. It is of the few theoretic-experiment methods, when transport equation of the transport theory of the radiation assumes an approximate solution in the suitable form for the spectrum analysis aims. The well-posed experiment's realization connected with the implementation of some conditions, when $\beta << 1$ and $m_{\alpha} l << 1$, where $\beta = \frac{1-\Lambda}{\Lambda}$ - specific absorption of the medium; $\Lambda = \frac{\sigma}{\alpha + \sigma}$ - the probability of the photon's "survival"; α - the absorption factor; σ - the dissipation factor; m_{α} - the natural index of the elementary volume's absorption; l - the size of the optical probe. Optical probe's peak value must be smaller than the average photon's free length and is determined by the next condition: $l \leq \frac{1}{\varepsilon}$, where ε - reduction factor of the scattered radiation. In our case, when the reservoir's dimension is: the height (h) is 0,5 m; the diameter (d) is 0,5 m, the optical probe's illuminating area maximum size may be assumed as 5x5 (mm), to avoid the interior wall's repulse influence $\rho_{ст}$ on the measurement result. The interior wall's repulse influence $\rho_{ст}$ is nearly 0,8. The length of the optical probe's beamguide L=0,4m, angular aperture $tg\varphi = \frac{l}{2L}$, $\varphi \approx 0.3°$. The depth, on which the abyssal regime is activated, depends on medium's beaming, probability of the photon's "survival" Λ and the scattering indicatrix's kind. Λ depends on the optical thickness $\tau = \varepsilon \cdot l$, which depends on the solution concentration (c). As the dispersion particle bigger, as the optical thickness (τ) is bigger and the probability of the photon's "survival" (Λ) is smaller. The brightness's changing B (z,θ) passes according to the exponential law:

$$B(Z,\theta) = B(0,\theta)\exp\{-\varepsilon'(Z - Z_0)\}, \qquad (1)$$

where $B(Z,\theta)$ - the brightness of the analyzed medium on its upper boundary, when, as a rule, z_0=0; z – optical depth on which the abyssal regime is installed. Under conditions of the abyssal regime the reduction factor ε' is determined as the slope ratio of the rectilinear dependence $\ln\left[\frac{B(z,\theta)}{B(z_0,\theta)}\right]$ on the depth z:

$$\varepsilon' = -\frac{\ln\left[\frac{B(z,\theta)}{B(z_0,\theta)}\right]}{z - z_0} = -\frac{d\ln E_{\downarrow}}{dz}, \qquad (2)$$

where $E_{\downarrow}$ - the illumination of the horizontal measuring area of the probe from above; $B(z,\theta)$ i $B(z_0,\theta)$ - brightness of the scattered beams on the angle θ. After the value's of the descending $E_{\downarrow}$ and the ascending $E_{\uparrow}$ illumination in the abyssal regime measuring we can find the exact value of the specific index of absorption of the analyzed dispersed medium. The probe has to have the flat reception surface (specular prism), moreover $E_{\downarrow}$ responds to the up-directed reception surface, $E_{\uparrow}$ - down-directed (low-level probe rotates to the 180°).

$$m_\alpha = \overline{\mu}\varepsilon' = \varepsilon'\frac{E_{\downarrow} - E_{\uparrow}}{E_0}, \qquad (3)$$

where E_0 - the spatial illumination with the spherical probe.

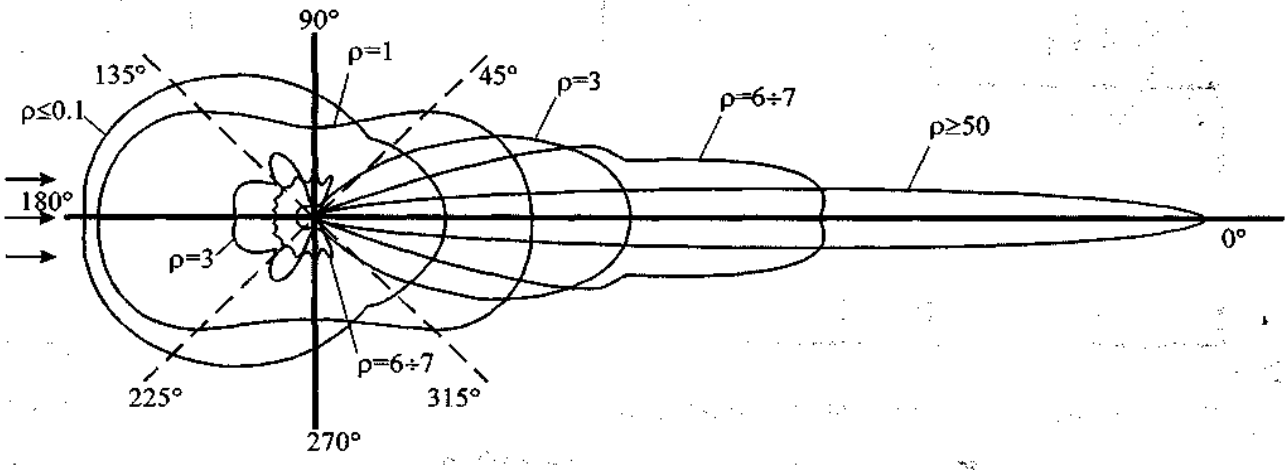
However, in case of the water colloidal solution, for example, milk or water contaminated with oil, the obtained m_α equals to the sum of the indexes of water absorption $m_\alpha^в$ (or other solvent) and diffuser:

$$m_\alpha = m_\alpha^в + cm'_\alpha, \qquad (4)$$

where c – the diffuser's concentration (dispersed particles) [1].

When we know m'_α of the dispersed particles, we can evaluate the average radius (a), quantity (n) of the dispersed particles in the unit of volume. Besides, the correlation between the size of the particle (a) and the wave length (λ) forms the "parameter Mi", which characterize the shape of the scattering indicatrix:

$$\rho = \frac{2\pi a}{\lambda}. \qquad (5)$$



Pic. 1 Scattering indicatrixes (bodies of the brightness) of the water-dispersed medium.

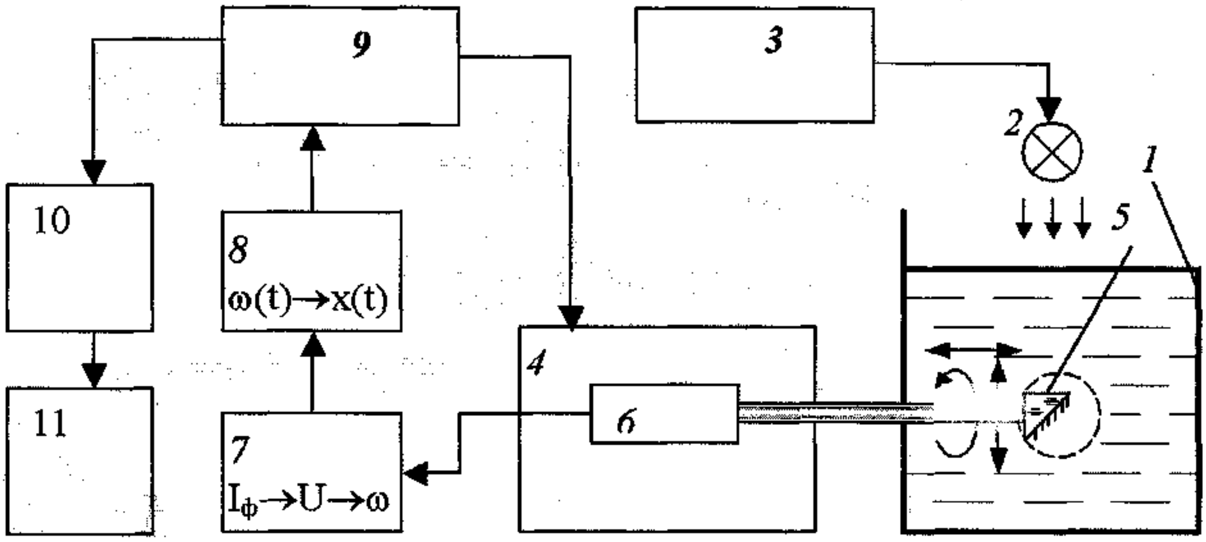
The scattering indicatrix depends on the ρ value. The value $\rho \le 1$ shows us that the indicatrix situated in the oncoming zone of the wave front. When $\rho > 10$ scattering indicatrixes are stretched ahead of the ray's fall route. In case when the wave length commensurate to the particle dimensions *($\lambda \approx a$, $\rho \approx 3 \div 10$)* we can observe the full-blown interference, which are caused by the superposition of the diffracted and the beated back light. So the forms of the bodies of the brightness indicate the size of the dispersed particles.

Such hydrophysics analyses are very important in the view of the location and meteorological optical range of the dark object's detection in polluted water mediums [2]:

$$m_\alpha = \frac{1}{S_M} \ln\left(\frac{1}{k^*} + 1\right), \qquad (6)$$

where S_M - meteorological optical range; k^* - eye's contrast threshold according to the brightness.

Functional scheme of the system is represented on the picture 2. The system includes: 1 – the reservoir with the analyzed medium, 2 – the emitter, which is connected to the power system (3). An automatized kinematic block of the probe's transfer – 4 is affixed to the reservoir 1. The automatized kinematic block of the probe's transfer includes a probe with the optical sensing device (prismoidal or spherical) – 5, which is connected to the photodetector – 6 with the flattener from the photocurrent into the frequency – 7, which is connected to the forming block of the digital code – 8 and correlation with the peripheral device (adapter) – 9, which transfers the obtained information to the computer – 10, where the information is processed with the software – 11.



Pic.2 The block scheme of the optical control-and-measuring system for the ecological monitoring of the water body's condition

All optical information about the light's field condition inside the light-diffusing medium is save in the computer's memory, where the information is agreed, processed and displays in the tabular, analytical and graphic presentation dependence of the brightness: $B_z = f(\Theta)$; $B_\Theta = f(z)$; $B_z = f(c)$, where z – the depth of the medium's layer, on which we carry out the measuring. The depth is counted off the dispersed medium's surface. Θ is the polar angle of the probe's rotating relatively to its zero position within the limits of $0° \leq \Theta \leq 180°$; c – the concentration of the analyzed medium. A Deep_mode program was created to manage the measuring system from the computer.

The developed spectrophotometric system may be used for the pollution's index detection, holding an ecological monitoring of the sewage's parameters including hanging substances. The research results were approved at the specialized departments of the State administration of the ecology and natural resources of Vinnytsya region, South Bug basin administration, Vinnytsya fat-and-oil industrial complex and milk plant.

The literature

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