https://doi.org/10.31891/csit-2025-2-6
UDC 004.942

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KEY ASPECTS FOR THE DEVELOPMENT OF INFORMATION AND MEASUREMENT SYSTEMS FOR DETERMINING ENVIRONMENTAL POLLUTION

The intensification of production at petrochemical, construction, industrial, and energy companies and the aging of equipment at major technological and energy facilities lead to increased emissions of toxic and dusty substances into the air, soil, and water. As a result of the ecosystem cycle, these chemical compounds enter the soil and water, causing pollution.

The main task of environmental expertise is to determine the degree of risk and safety of industrial activity, organize a program of expert assessment of industrial production facilities, establish compliance of facilities with the requirements of environmental legislation, examine the quality of natural resources, form a balance of quality criteria for the environmental safety of facilities and the environment, assess the negative impact of industrial and municipal structures on the environment, and expertly evaluate programs for the introduction of new technology.

Air monitoring is necessary to detect the effects of pollutants and their impact on: corrosion of structures, erosion of land resources, impact on human health, impact on flora and the environment, water pollution, and food contamination.

The article highlights the basic concepts for building information and measuring systems (laser concentrometer and opto-galvanic sensors) for rapid analysis of environmental pollution such as air, water, and soil in emergency and extreme situations. The air and water pollution was detected around energy facilities and various industrial production facilities that are at risk of military attack. The article describes the development and construction of a laser information and measurement system for measuring dust in the atmosphere and presents the results of a study of the chemical pollution of water wells in various industries.

Key words: sensor, information and measuring syste, monitoring, environment, pollution.

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КЛЮЧОВІ АСПЕКТИ РОЗВИТКУ ІНФОРМАЦІЙНО-ВИМІРЮВАЛЬНИХ СИСТЕМ ДЛЯ ВИЗНАЧЕННЯ ЗАБРУДНЕННЯ НАВКОЛИШНЬОГО СЕРЕДОВИЩА

Інтенсифікація виробництва на підприємствах нафтохімічної, будівельної, промислової та енергетичної галузей, а також старіння обладнання на великих технологічних та енергетичних об'єктах призводять до збільшення викидів токсичних і пилових речовин у повітря, ґрунт і воду. В результаті кругообігу речовин в екосистемі ці хімічні сполуки потрапляють у ґрунт і воду, спричиняючи їх забруднення.

Основним завданням екологічної експертизи є визначення ступеня ризику і безпеки промислової діяльності, організація програми експертної оцінки об'єктів промислового виробництва, встановлення відповідності об'єктів вимогам природоохоронного законодавства, експертиза якості природних ресурсів, формування балансу якісних критеріїв екологічної безпеки об'єктів і навколишнього середовища, оцінка негативного впливу виробничих і комунальних структур на навколишнє середовище, експертна оцінка програм впровадження нових технологій.

Моніторинг повітря необхідний для виявлення впливу забруднюючих речовин та їх впливу на: корозію споруд, ерозію земельних ресурсів, вплив на здоров'я людини, вплив на флору та навколишнє середовище, забруднення води, забруднення продуктів харчування.

У статті висвітлено основні концепції побудови інформаційно-вимірювальних систем (лазерний концентрометр та оптико-гальванічні сенсори) для експрес-аналізу забруднення навколишнього середовища - повітря, води та ґрунту - в аварійних та екстремальних ситуаціях. Виявлення забруднення повітря та води здійснювалося навколо енергетичних об'єктів та різних промислових виробництв, які знаходяться під загрозою військового нападу. У статті описано розробку та побудову лазерної інформаційно-вимірювальної системи для вимірювання пилу в атмосфері та наведено результати дослідження хімічного забруднення водозабірних свердловин у різних галузях промисловості.

Ключові слова: датчик, інформаційно-вимірювальна система, моніторинг, навколишнє середовище, забруднення.

Introduction

The second most important source after the intensification of production is the discharge of process water into water bodies and rivers from power plants and chemical and construction companies. One of the most powerful sources of emissions into the ecosystem after intensification is thermal power plants, which pollute the water and air of the environment.

Analysis of literature sources

Works [1,2,3] describe the conversion of fuel resources into energy resources using water as the basis of the conversion process, which is the carrier of thermal energy of fuel during combustion, into the kinetic energy of the turbine, which is transferred to the generator and converted into electricity. Channels and sensors for collecting data on the state of power unit units are also displayed and critical areas for their selection are identified.

To control the technological state of production processes and the environment, it is necessary to have a set of information and measurement systems that provide the selection of heterogeneous data from objects and the environment, assessment of state parameters, information technologies for interpreting images of situations formulated from blocks of selected terminal data and identifying their intellectual content regarding the target state of the man-made production and environmental complex [3-8].

The works of world scientists [9-13] outline the main environmental problems in the construction of sensors for measuring environmental pollution.

Materials and methods

To develop environmental monitoring systems, both local and global, to assess the state of the environment and the impact on social infrastructure and living spaces, it is necessary to use modern scientific methods based on the basic principles of control theory to describe potentially hazardous objects with an aggregated hierarchical spatially dis-tributed structure, system analysis of energy management processes, mathematical logic, decision-making theory to build effective strategies for coordinating management in case of threats to the load mode and attacks at all levels of the hierarchy; theory of expert systems for assessing the situation and classifying data on the state of the environment around the object; methods of laser remote sensing theory for building photometers and information and measurement systems; data collection on the concentration of dust in the atmosphere and water solutions in the environment, both stationary and portable.

The problem of developing information systems for environmental assessment of the environment state around man-made facilities

The problems of monitoring the state of the ecosystem and socio-communal infrastructure in the presence of large industrial man-made energy-active complexes that are polluters are solved on the basis of new information-measurement technologies and the following tasks are being solved:

1. identification of sources and channels of environmental impact (industrial, domestic, natural) based on sampling;

2. development of data sampling tools and their accuracy, objectivity, reliability in relation to the target tasks based on information technologies;

3. improved information technologies for data processing and interpretation of the content of environmental situations based on the integration of systems;

4. development of a classification of situation methods based on expert assessments using databases, knowledge and expert systems in the structure of the DMSS (Decision making support systems);

5. development of data management and storage systems (DS - data storage, DDP - digital data processing);

6. development of primary and secondary standards for quality criteria and chemical pollutants (SO_2, NO_2, CO, O_3, Pb) and sampling for active ions $\langle SO_4^-, Cl^-, NH_4^+, NO_3^-, Ca^{++}, Mg^{++}, K^+ \rangle$ and components of radioactive fallout.

The monitoring tools are: sampling of water, air, compounds, methods of physical and chemical analysis and data processing, equipment for physical and chemical analysis, systematic interpretation of results.

The monitoring results form the basis for obtaining data and information on the components of the impact and their level: primary data from sensors and PCs, data on the physical and chemical composition of pollutants, assessment of the level and degree of danger of pollution impact on the environment, assessment of the composition and volume of pollution emissions.

Air pollutants include:

- gaseous inorganic substances $\langle SO_2, H_2S, NO_2, Cl_2, CO, SiF \rangle$;
- mineral acids $\langle HCl, HF, H_2SO_4, HNO_3 \rangle$;
- radionuclides (strontium, cesium, iodine, plutonium, radium);
- simple organic substances (formaldehyde, benzopyrene, etc.).

Water is an important vital and technological resource of natural origin. Safe, it is an essential resource for life, industrial and agricultural development, and therefore effective management of water consumption based on monitoring the state of water in the structure of the region's resources is necessary. As a link in the natural cycle, water is divided according to the source of the resource into: surface water, underground water (in rock stra-ta), and marine water (seas and oceans). A water body is a naturally formed or artificially created object, such as streams, swamps, rivers, underground springs, reservoirs, and seas.

For thermal power plants and the social sector, we classify the types of water use: special, non-special, and general.

Environmental status is an expression of the quality of the structure and functioning of water systems. It takes into account: the physical and chemical structure of water, characteristics and parameters of its flow, chemical state and level of pollution. A water quality standard is a set of water quality indicators that cannot be exceeded for the sake of human health and the ecosystem (limit values beyond which structural destruction of the system occurs). Water quality classes based on integral pollution are determined on the basis of the legal provisions of the Water Code (7 classes in Germany). Water monitoring systems are classified according to the type of water: natural, waste, and saline.

In order to make informed management decisions in the field of environmental protection, it is necessary to create an information and measurement distributed mul-ti-parameter system, as well as a bank of environmental and technological data in the structure of an expert decision support system for process control.

Methods for assessing the level of concentration of harmful impurities and dust in the technological and atmospheric environment using laser sensing

The method of controlling the atmospheric pollution by combustion products from thermal power plants and dust from the construction industry by laser sensing is shown in Fig. 2.

Depending on the level of dust concentration and its dispersion, the laser beam is scattered and the power is reduced, while the level of losses depends on the dust concen-tration and its structure, which accordingly requires the construction of appropriate scales for assessing the parameters of the dust environment.

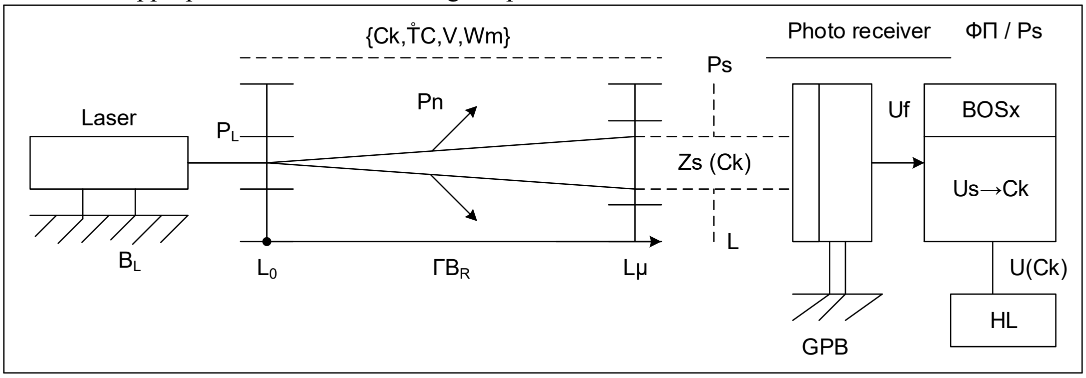

Figure 2. Scheme of laser sensing of dust pollution of the environment of man-made systems with indus-trial waste

Symbols in the diagram: B_L - geometric basis of the laser, P_L - laser power, L_0, L_μ - basis of the geometric environment with contamination $ГB_R(L_0, L_\mu)$;

P_S - beam power at the output of the control area, P_n - power of the scattered laser beam, GPB - geometric basis of the photodetector $(ФП/P_S)$, $U_f(Z_S)$ - voltage of the laser signal at the output of the photodetector after the processing of the probing beam $Z_S(C_K)$, $BOS_{ФП}(U_S \to C_K)$ - photodetector signal processing unit for information transformation in order to assess the concentration of air pollution by emissions of process products in the control area.

Methods of laser diagnostics of high-temperature coal dust and combustion products flows in power units of thermal power plants

An important problem is to control the level of concentration of coal dust flows into boilers after coal mills and the concentration of combustion products at the outlet, when they are sent to the chimney system.

Coal from different deposits has a ballast rock, which makes up (from 5% to 45%) of the content. When grinding in mills, coal dust is fed into recuperators to heat the stream (400-900^{0}C) before entering the boiler furnace. Changes in the composition of coal dust lead to a decrease in the level of useful content and a decrease in energy activity. When the concentration of the ground coal content changes, dynamic concentration emissions occur $\{C_i\}$, which can lead to an accident.

The requirements for controlling the concentration of the high-temperature mixture are satisfied by laser methods of remote sensing of the process medium through optical windows in dust ducts. The laser method of concentration control in the continuous mode of the gas-dust mixture flow in the dust ducts of power units is based on the estimation of laser beam losses due to photon scattering on dust particles moving in the dust duct flow during its transverse sensing through optical windows. Such windows are embedded in the cross-section of the dust duct and are permeable to a laser beam passing through the flow of a dust-gas mixture of fuel combustion products in the power unit boiler, which can change when passing through the recuperator within the limits of (300-600)^{0}C.

Fig. 3 shows a diagram of the process and structure of the laser sensing system for high-temperature coal dust entering the power unit boiler from the mills.

The notation in the diagram of Fig. 3:

SGm - specified generator with laser modulation frequency $(f_\mu = 625Hz)$;

PI - pulse amplification unit for powering a semiconductor laser (red spectrum $\lambda = 680n\mu$;

L_Z - laser emitter;

RN - ranking unit of evaluation normalization;

BDP - a laser signal amplification unit from the photodetector, which separates the concentration level component after processing the modulated signal $\left(Z_S(t,\tau,f)\to U_S(f,t,\xi_t)\right)$ under the influence of an interference (ξ_t);

BAS - a unit for displaying the concentration level based on the balance method and alarming the level exceedance based on the assessment $(U(C_K))$.

In accordance with the method of sensing the environment (direct, reflected beam), a characteristic model is determined for ranking and assessing the concentration level of the high-temperature coal dust flow in the dust pipe of the power unit boiler.

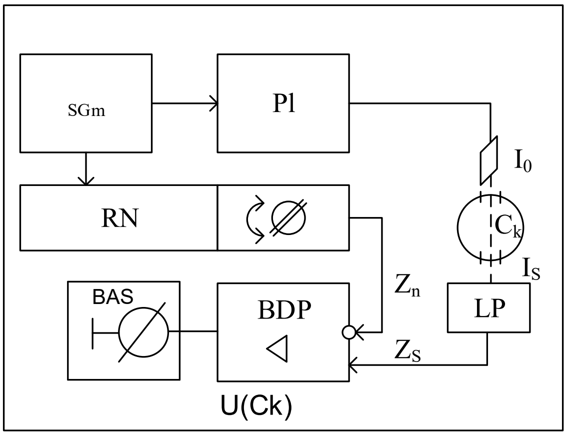

Figure 3. Diagram of the process of sounding the dust pipeline of the power unit

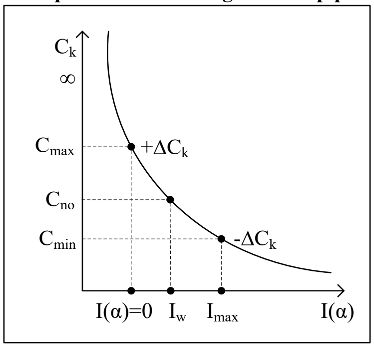

Figure 4. Characterization model for estimating the level of dust and impurities Concentration

The estimation of the intensity (energy) of the scattered laser beam of the corresponding concentration level at the output of the optical window in the dust pipe is based on the measurement transformations of the laser sensing signal (Fig. 3, 4):

- beam energy conversion during laser sensing: $I_s(t,S_c)=I_0\exp(-\alpha L(C_K,S_L))$
- selection of information about the dust concentration in the control area: $\exp(-\varphi_c(\alpha,S_e,C_K))=I_s(t,S_e)\cdot I_0^{-1}$
- determination of the dust concentration function after processing the scattered signal by dust: $\varphi_c(\alpha,S_e,C_k)=\ln(I_S(t,S_e)/I_0)=-\ln I_S(t,S_e)+\ln I_0=\Delta\ln(\psi(I_S,I_0))$;
- evaluation of the imbalance of the level of dust concentration in the dust wires is formed in the rank discriminator at the output of the processing unit (PU) based on the transformation: $L_S\xrightarrow{C\kappa}U_{\Phi\Pi}(C_\kappa,t,\tau)\to U(\text{f},C_K)\to U(\hat{C}_K)\to Rang\left(U(\hat{C}_K)\right)\to Rang_i\left(\hat{C}_K\right)/_{I=1}^{m}$
- determination of emergency $Rang\dfrac{ALARM}{AVAR}$ (concentration alarm condition or pre-emergency condition of the power unit by the generator power limit load).

Laser sensing of contaminated water and process liquids in combination with the optical-galvanic method of assessing the concentration of harmful substances

For comprehensive monitoring of water in the reservoirs of thermal and nuclear power plants to obtain a complete set of data on the level of chemical and dust contamination of water, it is necessary to use an integrated approach to analyze the concentration of pollutants – technological process wastes in the generation of electricity.

The integrated control method includes:

- laser sensing of liquids, gases, combustion products in gas boilers;

- use of chemical, physical and optoelectronic sensors to analyze the composition of substances;
- optical-galvanic laser control methods.

In accordance with the developed method of synthesizing a concentrator based on a laser photometer model, experimental stands for optical and galvanic studies of physical effects in technological environments, for the energy, oil and printing industries were created. To intensify data collection processes by laser sensing of samples in cuvettes, which provides a higher level of sensitivity and their chemical composition. Fig. 5 shows a diagram of the developed stand for conducting experiments on the complex optical and galvanic interaction of a laser photon beam with the substance of the sample to assess the composition of aqueous solutions and electrochemical structures.

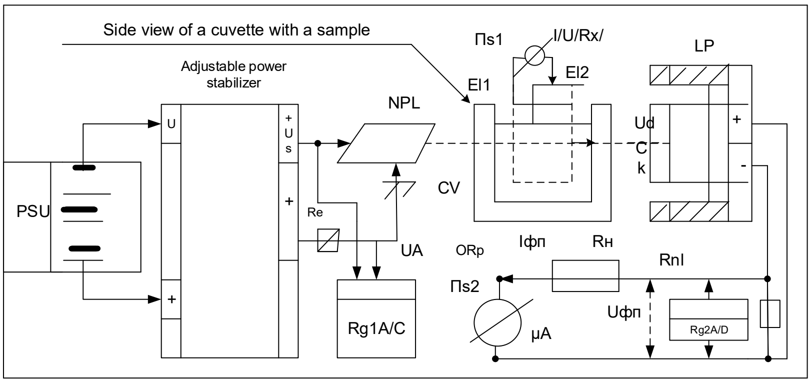

Figure 5. Stand for the study of laser effects of active interaction of substances in solutions

The block diagram includes the following units:

power supply with adjustable voltage regulator in the range $U_S \in [0-5]V$ for chang-ing the laser power;

- Rnl - load of the laser signal photodetector;
- Rd is the calibration resistance of the photoelectric signal from the matrix;
- A/C - voltage and current multimeter with a device for recording measurement data during the experiment;
- NPL - semiconductor laser with power (5, 50, 1000 mW);
- BL - geometric base of the laser and photodetector installation;
- CV - transparent cuvette with a solution of chemical components in water;
- $\{E_{li}\}$ A set of electrodes (zinc, copper, silver, carbon);
- Π_{SI} - an arrow (A/D) device for controlling the voltage (current) between electrodes E_{li} in the mode of controlling the optical-galvanic signal conversion due to quantum effects;
- PD - Photodetector of the laser signal after its passage through the cuvette with a sample of contaminated liquid and water reservoir;
- Π_{S2} a device for monitoring signals by sections of the photodetector.
- $Rg_2(A/D)$ voltage registrar at the output of the photodetector, which is generated at the moment of receiving a laser signal on the photodetector matrix and is allocated to the load resistor RU .

Models of sensors for monitoring the concentration of harmful water pollution in thermal power plant (TPP) reservoirs based on the use of optogalvanic effects

The basic model of an optical-galvanic sensor is a combination of galvanic pairs of dissimilar metal electrodes (Cu/Zn) that generate electromotive force in a liquid medium due to $\varepsilon_S = \varphi_{1(Zn)} - \varphi_{2(C\varepsilon)}$ electrode potentials (φ_1, φ_2) and activation of the liquid at the quantum level by laser photons

$$(H_2O/C\kappa) \to \left(\varphi_1 \underset{C\kappa}{\overset{KVj}{\otimes}} \varphi_2 \right) \to \langle U_{1,2}(C\kappa), I_{1,2}(C\kappa) \rangle$$
$$(P_{Zl}) \to \lambda_i \to \quad \uparrow\uparrow \leftarrow (P_{Sl})/(C\kappa)$$

where: C_K - concentration of harmful emissions, (φ_1, φ_2)- potential of galvanic inter-action, Kvj - quantum photon effects of laser excitation, (P_{Zl}, P_{Sl})- power of the probing and scattered laser beam, $I_K(C_K)$- current in the galvanic couple circuit.

Let us consider the characteristics of concentration sensors using optical-galvanic effects. Here is a diagram of a measuring system for a comprehensive study of an aqueous solution and the concentration of impurities in solutions based on the method of a comprehensive experiment on laser sensing and optical-galvanic generation of dynamic elec-tric potential to determine the level of concentration of chemicals in the products of harmful emissions during the technological process into the water environment of the TPP reservoir based on samples taken for the optical cuvette (OKp).

Based on the studies of the interaction between the laser beam energy and the aqueous medium, a signal is generated in the galvanic couple (E_{11}, E_{12}) and a laser signal is formed at the cuvette output. Based on the laser optogalvanic effect, a concentrometer scheme was developed (Fig. 6)

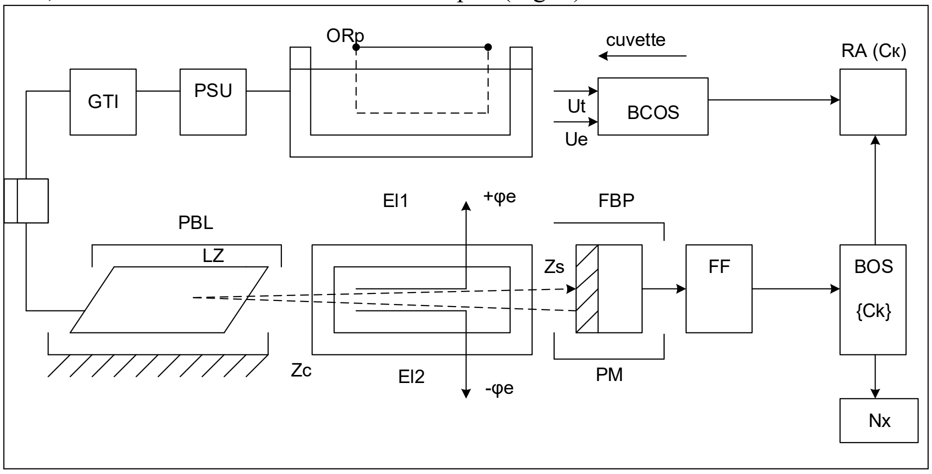

Figure 6. Schematic diagram of an optical-galvanic sensor for sampling data on the level of con-centration of impurities in water

Symbols in the diagram: PSU - power supply unit, GTI - pulse generator for laser modulation, Lz - laser for probing a sample in a cuvette, $Zc(t, Pz, fi))$- probing laser signal with power and frequency , PBL - photo blend of laser protection, OCr - optical cuvette with a sample, (E_{l1}, E_{l2}) - electrodes of the galvanic sensor, PZ_s - signal power at the output of the cuvette, PM - photomatrix, FBP – photographic protection hood of the matrix photodetector, FF - filter unit of the laser signal after conversion in the photomatrix, BOS is a signal processing unit for estimating the level of impurity concentration in a water sample after laser sensing, - is an analog-to-digital signal converter for estimating the concentration in a discrete (digital) form of representing information about the level of water pollution, BCOS is a unit for complex processing of optical-galvanic signals from electrodes (E_{11}, E_{l2}), RA(Ck) is an analog signal recorder from optical-galvanic and laser sensors.

The laser optical-galvanic effect when sensing samples in an optical cuvette in which the supplied water is contaminated with TPP emissions (combustion products) is the ba-sis for generating two physically different signals:

Laser sensing signal at the output of the optical cuvette (cell) of a water sample with impurities with a certain concentration level

$$(Z_G, P_C) \to R_{VS}(C_K) \otimes (P_Z, Z_S) \to (\alpha_S^{C\kappa}, P_Z) \to P_S(C_K)\ ,\ P_S(C_K) \xrightarrow{\alpha\Phi\Pi} U_{\Phi\Pi}(P_S(C_K)) \xrightarrow{Kus} \left\{ \hat{C}_K \right\}$$

where K_{us} is the normalization factor for estimating the concentration of impurities in laser sensing.

The signal of a galvanic couple immersed in a cuvette with a water sample from a reservoir with a certain level of pollution concentration is formed according to the diagram of optical-galvanic quantum interaction during laser sensing of contaminated water samples

$$\begin{matrix} (H_2O + R(C_K)) \\ \{P_Z\}.............\to \end{matrix} \to \otimes \begin{matrix} \xrightarrow{E_{l1}} \\ \xrightarrow[E_{l2}]{} \end{matrix} Np \to \Delta U_K(P_Z, C_K, R(C_K)) \to \langle\ C_K / (\hat{I}_{12}(C_K))\ \rangle\ ,$$

According to the research scheme, the variable parameters are:

- voltage, current, radiation power of a semiconductor laser due to a change in the voltage of the stabilizer, while we have

$$V_{Ar}(U_S \in [0-5]B) \to V_{Ar}(P_L \in [0 - P_{\max}])\ ,$$

- change in the concentration of impurities dissolved in the liquid in the cuvette $C_{Kd} \in [C_{K\min}, C_{K\max}]$

Taking into account the formulated methodology for assessing the level of impurity concentration, let’s obtain functional characteristics:

- Concentration level $C_K \to U_{\Phi\Pi}(P_S(C_K))$ at $P_L \in \{P_i - const, P_i \in [0-500] mBm\}$
- Photodetector output voltage as a function of concentration

$$U_{\Phi\Pi}(C_K) \to \{U_{\Phi\Pi}(P_S / C_K) / P_L - const, C_{Ki} - V_{ar}\}$$

$$U_{\text{ФП}}(C_K) \rightarrow \{U_{\text{ФП}}(P_S / C_K)/ P_L - V_{ar}, C_{Ki} - const\}$$
$$I_{\text{ФП}}(C_K) \rightarrow \{\varepsilon_{\text{ФП}}(P_S / C_K)/ P_L V_{ar}, C_K - const, R_A - const\}$$

The construction of calibration characteristics in relation to the concentration of impurities is based on

$$U - (C_K) = \psi(P_L, C_K), , I_{\text{ФП}} = \psi(R_H), U_{\text{ФП}} = \psi(R_N)$$

A low-sensitivity logarithmic scale concentrator of impurities in solution with compatible measurements is described by a system of equations that relate the level of impurity concentration to the voltage, current, potential and current of the active electrodes (Cu, Zn) for an optical galvanic sensor. $I_X = I_0 \exp(-\alpha(C_K) l_K)$

$$\alpha(C_K) l_K = \ln I_x - \ln I_0 ,\ \alpha(C_K) = \frac{1}{l_K}[\ln U_{\text{ФП}}(P_X) - \ln U_{\text{ФП}}(P_0)]\ \ P_Л = U_{\text{ФП}}(I_Л) \cdot K_{U,P}$$

$$C_K = \psi(\alpha, V_K, l_K) \cdot \Delta U_{\text{ФП}}(\ln U_X - \ln U_0)\left[\frac{мг}{см^3}\right], U_{\text{ФП}} = I_{\text{ФП}} R_i$$

where: C_K - concentration of impurities; α - reduced scattering coefficient; $U_{\text{ФП}}$ - photodetector voltage; (V_K, l_K) - volume and length of the cuvette; $Rg(A/D)$ - analog-digital data logger; IФП - photodetector current; Ri - load resistance.

In accordance with the functional diagram, the measuring characteristics of the concentrometer (Fig. 7) are formed experimentally, taking into account the power of the prob-ing laser.

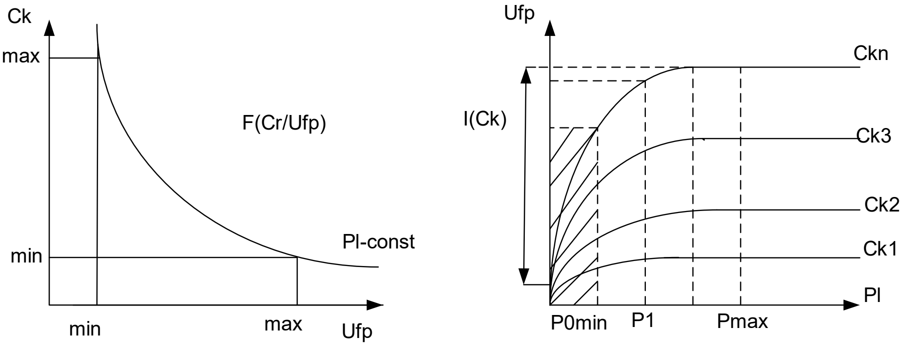

Figure 7. Characteristics of concentration measurement

The graduation characteristics of the sensors of impurity concentration in solutions and dust streams have the same model. The graduation characteristics (laser - photode-tector) are represented as a system, where $P_л[mBB] \in [0 - 500] mBB$ is the laser power; $I_{\text{ФП}}[mA] \in [0 - 500] mA$ photodetector current at different loads Ri.

Discussion of research results

Thus, based on the work results, we can formulate the following scientific novelty and practical significance of the research results.

The scientific novelty of the research results is the developed concept based on new information and system technologies and laser remote sensing, the method of integrated use of physical, chemical, and optical effects for the development of new type sensors, the substantiation of their information and metrological structure, synthesis methods and methods of experimental and scientific research.

Practical significance of the research results - the results of the work and analysis of global trends in the field of thermal energy, the implemented laser concentrator at Burshtyn TPP is the only project implemented in the world practice of monitoring the combustion of high-temperature fuels. Ion-selective sensors are widely used in analytical instruments and monitoring systems that are mass-produced in Ukraine and worldwide. The optical-galvanic sensors concept proposed by the authors is used to control the concentration of various impurities in the water environmental based on analytical experiments in the laboratory at the reservoir of Burshtyn TPP and other types of production, such as

1. Elevator, Rohatyn city;
2. Furniture factory in Radekhiv city;
3.Barn, village of Bibshchany;
4.Poultry farm, Hnizdychiv village.

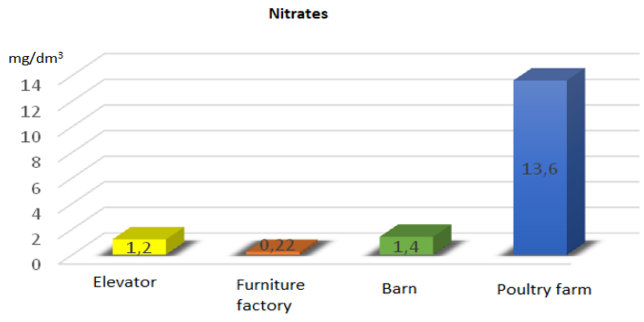

Figure 8. Chemical analysis of water from the well for 2023, the maximum concentration limit for nitrates is 50.0 mg/dm3

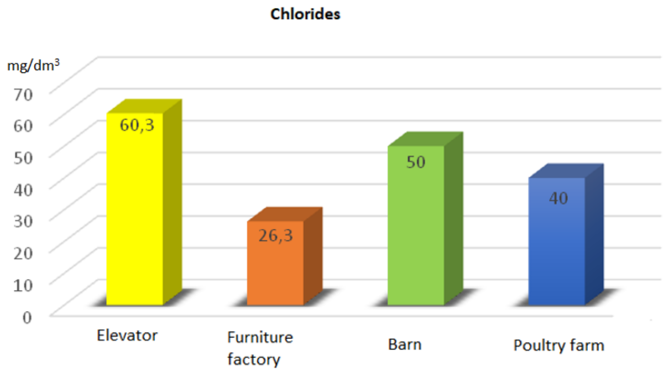

Figure 9. Chemical analysis of water from the well for 2023, the maximum concentration dose for chlorides is 300 mg/dm3

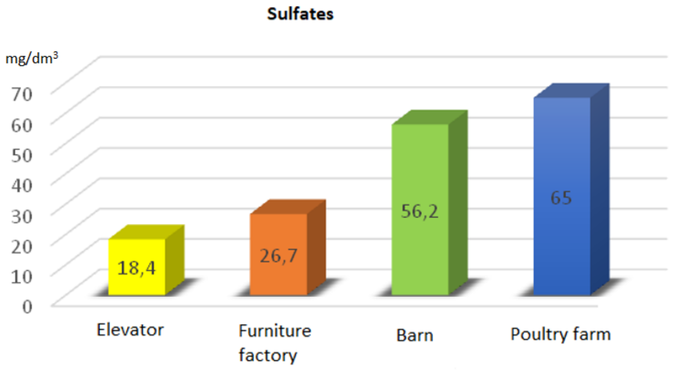

Figure 10. Chemical analysis of water from the well for 2023, the maximum concentration dose for sulfates is 500 mg/dm3

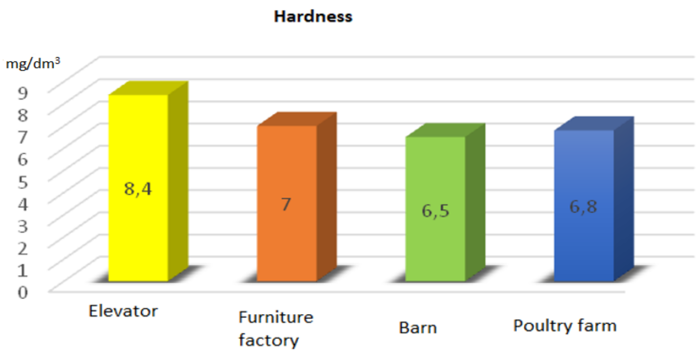

Figure 11. Chemical analysis of water from the well for 2023, the maximum concentration limit for Hardness is 7.0 mg/dm3

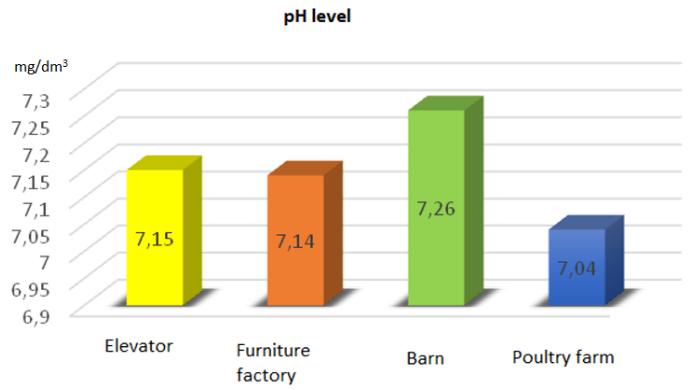

Figure 12. Chemical analysis of water from the well for 2023, the concentration limit for pH is 6.5-8.5 mg/dm3

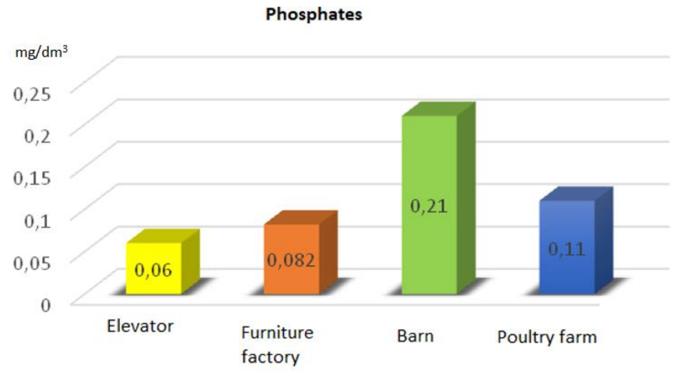

Figure 13. Chemical analysis of water from the well for 2023, the concentration limit for Phos-phate is 3.5 mg/dm3

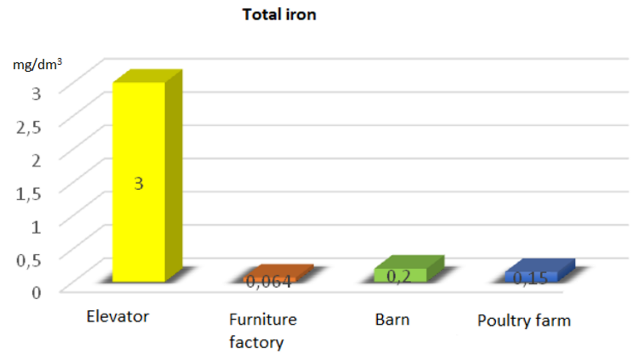

Figure 14. Chemical analysis of water from the well for 2023, the concentration limit for total iron is <1 mg/dm3

As can be seen from the graphs of water pollution from wells, we can conclude that poultry farms are the largest polluters in terms of nitrates, chlorides, and sulfates. The second place is occupied by cowsheds.

Conclusion

The article presents the theoretical foundations of creating laser sensors for measur-ing the concentration of harmful process components that enter the atmosphere and water bodies of the ecological environment of production facilities.

The article reveals the creation of information technology for the selection, processing, and classification of expert data on the state of the ecosystem of a technological facility based on the use of laser sensors to measure the concentration of harmful emissions in the air, groundwater, and water bodies.

An information model of laser sensors for measuring the concentration of harmful components in solutions and the atmosphere, which are fuel combustion products in boilers, has been developed.

The article presents elements of information technology for decision support based on the processing and classification of data from laser and optoelectronic sensors and methods for developing laser sensors for monitoring the concentration of technological hazardous waste in the atmosphere and solutions.

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