Ultrasonic system for operational ecological control of water pollution

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***Abstract* – the work is dedicated to the issues of the developing the methods of the data-processing system creation for the ecological control of the water pollution. It was created the methodological approach towards the solving of the tasks based on the simultaneous measurement of the integral, selective and hydro-physical parameters and geographical coordinates.**

Key words – ecology, data-processing system, ecological monitoring, aquatic medium, measurement, integral, selective, hydro-physical, parameters.

I. Introduction

At our time the ecological pollution problem is one of the most important problem in the world. Water pollution from human activities increases every day.

So the ecological environmental monitoring need appears. The operative aquatic medium monitoring provides the real time observation of the separate objects data in the breakdowns areas and ecological emergency zones and making decisions on its elimination.

Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use, such as drinking water, and/or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish. Natural phenomena such as volcanoes, algae blooms, storms, and earthquakes also cause major changes in water quality and the ecological status of water.

The number of water pollutants is up to hundreds of thousands. The selective measuring means can determine only one polluting component. Therefore, to determine the operational aquatic medium status the integral settings should be used. The contamination criterion is the total content of inorganic and organic admixtures in the water. Presently, there is an urgent development of the operational integral method for the total water admixture content determination.

The aim of this work is the development of the methods and means which help to improve the accuracy of the computerized data-processing system for the operational ecological monitoring of the aquatic medium.

II. The principles of the creation of the data-processing systems for the operational ecological monitoring

The model of the aquatic medium includes the near-water atmosphere layer, layer of aquatic medium and bottom sediments. The aquatic medium is characterized by the presence of admixtures and small-scale rotations and velocity vp.

Methodology is proposed for this model, of the data-processing system construction for the operational ecological monitoring of the aquatic medium that consists in the simultaneous measurement of the integral, selective and hydro-physical data and geographical coordinates [1].

The operating equation of the information transferring, selection and transformation process for the operational aquatic medium data determination including constructional parameters is as follows

$$[P_i\{C_\Sigma; \sigma; T; pH; Eh; \gamma\}; P_c\{C_i\}; P_h\{v_x, v_y, v_z; c; rot\, v; H\}; P_g\{\beta; \varphi\}] = =F\{t_1, t_x; t_2\}\{L, p, \alpha, z\}[D, K_\alpha, K(\varphi), K_0], \quad (1)$$

P_i are integral parameters, in particular, C_Σ - total admixture concentration in the water; σ - electrical conductivity; T – temperature; pH – hydrogen ion concentration; Eh – redox potential; γ - nonlinear acoustic parameter; P_c – selective parameters, in particular, ingredients concentration C_i in the near-water atmosphere layer, aquatic medium and bottom sediments; P_h hydro-physical parameters, notably, v_x, v_y, v_z – stream velocity components, c – acoustic speed; $rot\, v$ – rotation component of the stream velocity; H – water level; P_g - geographical coordinates, latitude β and longitude φ; L – measurement basis; t_1, t_2, t_x, p, α - the input parameters, respectively, the durations of acoustic signals passing along the measurement basis in opposite directions or in model and examined liquids, the difference of those passing durations, the liquid pressure and absorption coefficient; D, K_α, $K(\varphi)$, K_0 – constructional parameters that include geometrical dimensions of the sensor, acoustic qualities of the aquatic medium, the chart direction, mutual sensors disposition in re each other; z – the value which characterizes inaccuracy of the model that consists of the following parameters: sensitivity variation of acoustic sensors, frequency resolution, stream velocity, the presence of turbulence etc.

The system block diagram for the aquatic medium monitoring synthesized. It includes measuring modules of integral parameters (MMIP), selective parameters (MMSP), and hydro-physical parameters (MMHPP). Each module includes measuring channels (MC), which consist of sensors (S), secondary measuring converter (SMC) and analog-digital converter [2].

The system for the operational ecological monitoring of the aquatic medium which applies ultrasonic, conductometric and ionometric methods was developed.

In order to improve the measurement accuracy of the total salts concentration in the water in this system, it is proposed to apply the method of model signals, which can reduce systematic and slowly changed error.

The block diagram of ultrasonic channel of the system is shown in fig. 1.

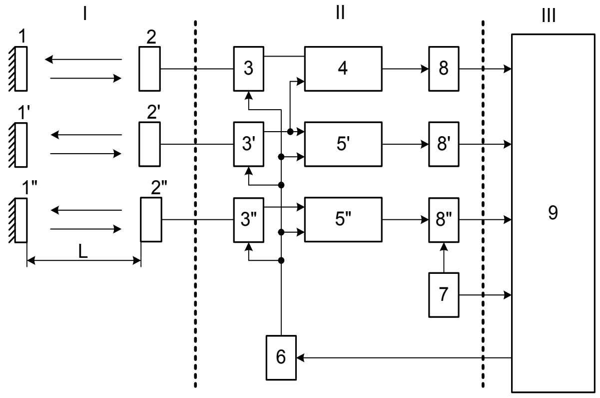

Fig. 1. The ultrasonic channel system

It can be divided into three parts: I – primary converters, II – time intervals meter, III – microcontroller. It works in the following mode: pulses with the frequency f_0 launch the probe generator 6.

The electrical probe pulse goes through commutators 3 and 3’ to inverse acoustic converters 2, 2’ and 2’’, which convert it into ultrasonic pulses. These pulses spread in the test and two model milieus on the basis with the length L, multiply reflecting from the reflectors 1, 1’, 1’’ and inverse acoustic converters 2, 2’ and 2’’, are gradually decaying in amplitude.

The general water concentration can be defined with the formula [3]

[illegible] (2)

α – inclination of the calibrated characteristics IBC; T1, *T2* – respectively, the time of ultrasonic signals spread in the channels with the concentration *C1* and *C2* , and T_V – ultrasonic signals spread in the channels with the unknown concentration.

The concentration *C* is the function of time intervals *Tv, T1* i *T2*, and concentration *C1* and *C2* obtained with the high degree of accuracy. The algorithm is realized by the microcontroller, which receives time intervals Tv, T1 i T2, and the parameters α, C1 and C2 are entered manually. The microcontroller calculates the total admixture concentration C and submits the digital data to a personal computer.

Conclusion

The new methodology of the data-processing system creation for the ecological monitoring of the aquatic medium is developed. It consists in its simultaneous measurement of the integral, selective and hydro-physical parameters and geographical coordinates.

An ultrasonic method for measuring the total admixture concentration in the water was proposed; it is based on the measuring the time parameters of the ultrasonic multiply reflected impulses in two model and one test milieus that allowed to reduce the errors of the concentration measurement. The principles of the computerized data-processing system creation were established.

The principles of the computerized data-processing system creation were established.

References

[1] V. Pohrebennyk, A. Romanyuk “Methods and tools for rapid analysis of water pollution” Materials of the twelfth open scientific conference faculty ITRE National University "Lviv Polytechnic", Lviv, 2009. - P. 52.

[2] V. Pohrebennyk, A. Romanyuk, R.Politylo “The Computerized System For The Operational Environmental Monitoring Of The Aquatic Medium”, proceedings of OWD’2013, 19-22 October 2013, Wisla.

[3] V. Pohrebennyk, A. Romanyuk, R. Politylo “Analysis of methodological errors in measuring the total concentration of impurities in the water”, Journal of the National Technical University of Ukraine 'Kyiv Polytechnic Institute ". Series of "making.". – K., 2012. – P. 72–79.