

Ministry of Education and Science of Ukraine

***Odessa National Academy
of Food Technologies***



International Competition of Student Scientific Works

BLACK SEA SCIENCE 2020

Information Technology, Automation and Robotics

Proceedings

Odessa, ONAFT 2020

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Black Sea Science 2020: Proceedings of the International Competition of Student Scientific Works. Information Technology, Automation and Robotics. / Odessa National Academy of Food Technologies; B.Yegorov, M. Mardar, S.Kotlyk (editors-in-chief.) [*et al.*]. – Odessa: ONAFT, 2020. – 365 p.

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DEVELOPMENT OF MOBILE APPARATUS AND MEASURING COMPLEX FOR WASTEWATER COMPOSITION CONTROL

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Abstract. *The purpose of the work is to consider the main anthropogenic sources of pollution of the water environment, to familiarize with the criteria of pollution of water bodies, analysis of methods for determining the level of pollution according to the relevant criteria, development of a hardware complex monitoring the status of sewage. The object of designing is a hardware complex of sewage monitoring.*

The development of the hardware complex is based on the review of existing analogs of hardware and software complexes, the development of appropriate

requirements for the creation of appliance and development of methods and tools for the implementation of this complex.

A general algorithm of the system as a whole and algorithms of each subsystem operation are made. They include algorithms for data collection, data processing and sending the latest to the server. It has chosen a way to connect device to the Internet. For data transmission GSM standard digital mobile communication is used. The GSM standard supports packet data (GPRS). Characteristics such as efficiency, network coverage, security are especially important for wireless data transmission.

Hardware and software complexes have proven themselves well in places of wastewater discharge on the relief and in reservoirs, including on remote production facilities.

Key words: *hardware, sewage, GSM standard, physico-chemical composition, turbidity, acidity*

I. Introduction

The continuous development of all sectors of industry, energy, agriculture and public utilities requires significant water consumption, as a result - increasing the amount of wastewater. By getting into surface and groundwater sources, wastewater pollutes them with harmful impurities that are dangerous for human life. The current state of Ukraine's water resources is in a critical position. Official statistics show that every year more than 300 million cubic meters of untreated wastewater are discharged into the reservoirs of Ukraine[1].

Conservation and protection of water resources from pollution is one of the most important problems of humanity. Special attention is paid to the protection of reservoirs from pollution by sewage of industrial enterprises, most of which are located in large cities. Currently, a large number of businesses continue to produce untreated or under-treated sewage. Effective pollution prevention and sewage treatment systems should be used to prevent the discharge of contaminated water.

This paper deals with the problem of water pollution. The purpose of the work is to develop water pollution control systems. The subject of the study is pollution control of the wastewater, the subject is the hardware quality control of wastewater. According to the goal, the main tasks and methods of solving the problem are: studying the basic characteristics of wastewater, developing a structural scheme of the hardware complex, developing algorithms for the modules of the complex, the calculation and selection of appropriate equipment. The wastewater pollution control system will identify and warn at an early stage about emergencies related to wastewater pollution. The main fields of application of this development are agriculture, mining, metallurgical and chemical industry, communal enterprises.

II. Analytical review of literature

Poor water quality is the result of irrational human activity on the planet. There are huge reserves of water on Earth, but the share of fresh water is only 2.5 - 3% of the total, with 85% of fresh water being contained in the form of ice. In some places, fresh water is

not enough to cover the needs of agriculture and industry, and in some places, even to meet the needs of domestic consumption [2].

As for Ukraine, 70% of the population is supplied with fresh water, however, according to monitoring data, 40% of the population consumes untreated water that does not meet sanitary requirements. Over the last ten years, the trend of water pollution has been decreasing, but this level remains quite high, as the water pollution level by industry has decreased by only 3% and the pollution by household water has decreased by 5%. Wastewater from livestock farms, irrigation of crops, minerals, acid rain, municipal runoff, water transport, radioactive waste come to the reservoirs and pollute them with bacteria and viruses [3]. Consider the main characteristics of wastewater.

Sewage is water formed as a result of the discharge of various industrial wastes, as well as atmospheric precipitation, which flows from the environment into the reservoir in contaminated form.

Sewage is divided into:

- domestic, which come from public utilities: wastewater from cooking facilities, toilets;
- industrial, formed as a result of various technological processes of heating or cooling of liquids, gases, any production, mine water of mines and quarries. Dangerous pollutants of industrial wastewater are residues of petroleum products, phenols, synthetic surfactants, heavy metals, organic substances with long decomposition, including various pesticides. Mine and mine waters have in their composition high mineralization, acid reaction of environment, a large number of mine elements, which are in dissolved and suspended forms. The wastewater of this subgroup is divided into contaminated and conditionally clean. Contaminated water needs pre-treatment before being dumped or reused; conditionally clean water does not require pre-treatment;
- atmospheric sewage formed by rain, snow, hail, watering. The wastewater of this group is usually contaminated with substances of mineral and organic origin. The level of wastewater pollution is expressed in the concentration and mass of impurities per unit volume (g / l or mg / l), as well as in the quantitative and qualitative composition of mineral, organic and biological pollution.

The composition of domestic wastewater is relatively uniform and is characterized by the presence of organic contaminants in the undissolved, dissolved and colloidal state. Accordingly, by physical condition, household sewage is divided into the following categories:

- insoluble - large suspended suspensions with particle sizes exceeding 0.1 mm, foams, suspensions and emulsions with particle sizes ranging from 0.1 μm to 0.1 mm;
- colloidal - particle size in the diameter from 1 nm to 0.1 μm ;
- soluble - molecular-dispersed particles, the size of which does not reach 1 nm.

By nature, pollution substances are divided into:

- mineral - contaminants include particles of sand, clay and slag, solutions of salts, alkalis, acids and other substances;
- organic - contaminants are of animal and vegetable origin.
- biological - contamination includes yeast and molds, microorganisms, algae and bacteria [4].

Formulation of the problem

Considering the effects of water consumption from polluted reservoirs, it becomes obvious that the problem of water quality in reservoirs is quite urgent and needs a comprehensive solution. The level of control and purification of reservoirs is extremely low today, which can lead to death. We offer a solution to the problem by controlling wastewater emissions.

The control over the operation of wastewater treatment plants and the pollutant emissions into the reservoir is carried out in order to prevent and stop the pollution of water bodies by untreated and insufficiently treated wastewater, as well as to reuse them in industry and agriculture. The practical importance of this work is to control the quality of achieving an appropriate level of wastewater treatment.

The necessary tasks of this work are:

- elaboration of literary sources on the topic of pollution of reservoirs, identification of important aspects of quality control of reservoirs;
- analysis of requirements for water quality criteria;
- analysis of existing analogues;
- development of algorithms of operation of the hardware complex;
- development and selection of the necessary components of the hardware complex;
- putting the finished product into operation.

Having analyzed the literature sources, the requirements for the criteria of wastewater quality have been analyzed and it has been found that the treated wastewater has to satisfy the following requirements:

- biochemical oxygen consumption does not exceed 50 mg / l
- no floating organic pollutants;
- the content of suspended particles does not exceed 60 mg / l;
- oil (condensate) content does not exceed 5 mg / l when extracted with ether;
- chromaticity - more than 20 units (platinum-cobalt scale);
- hydrogen index ph – 6-9 [6].

Overview of existing solutions

There are many different indicators of water quality. Depending on the prospect of further use of the test water, its analysis is carried out in the context of certain chemical or physical properties of interest at the moment.

Unfortunately, there are no universal instruments that allow one survey to conclude on all existing quality parameters. But there are quite a number of devices that can measure the general characteristics of the pollution level.

Analyzing the market of existing measuring and measuring complexes, we can conclude that there are a large number of devices with fairly similar functionality.

There is a demand for small-sized devices capable of real-time tracking of common water indicators such as temperature, acidity, turbidity. The field of application of the devices has no limits - hydroponics, fish farms, cultivation of various types of aquaculture, control of technological processes, laboratory and field research.

Let's look at competitors' measuring and measuring complexes and find out their advantages and disadvantages.

The analyzer of quality of water and solutions AZ-86021 (ph / DO) is intended for measurement of level of acidity (ph), temperature and concentration of dissolved oxygen in a liquid. The advantages of the analyzer are its small size, mobility and ease of use. The disadvantages of the device are the lack of ability to scale the device, the number of sensors is limited, there is no ability to automatically measure performance on remote sites.

The BlueBox System water analysis system is modular and scalable for projects of any size. It is possible to extend the base number of sensors. Data can be transmitted over the Internet or mobile telephone systems. The disadvantages of the system are its size, cost and complexity of installation and use.

PQ45 Portable Analyzer. The most popular measurement parameters for this system are chlorine and ph. The advantages of the system are its small size and ease of use. The disadvantages are the limited use of sensors and the inability to monitor water quality remotely.

900R water analyzer. The device is designed to measure ph, ORP, ion concentration, electrical conductivity, TDS, salinity, conductivity, and dissolved oxygen content analysis. The advantage of the device is the presence of a large number of parameters of the measured quality. The disadvantages of the device is the inability to automatically remotely control the water composition [7].

Analyzing the available analog devices, we can conclude about the basic functional characteristics that should be created by the hardware-programmable complex:

- device mobility;
- scale of the device;
- possibility of remote work.

The available characteristics make it possible to cover the shortcomings of the existing complexes and surpass their functionality, as a result - increasing the demand for the product among the existing competitors. The advantages of the hardware-complex are complemented by the software that has the ability to:

- storing information on a server that does not require additional disk space on the user's computer;
- universal customized web interface, no need to install additional software for mobile devices or personal computers, access to data is provided via the Internet;
- use the web server to manipulate the data, not deploy the server on the device.

Thanks to the ability to scale the complex, the cost of the device is much lower, unlike competitors, and may vary depending on the number of sensors required for the task. Advantages include the fact that the development of the system is the result of combining the hardware and measurement system with the appropriate software. This fact provides the ability to use the system conveniently unlike competitors who require separately installed special software or performance metrics without remote monitoring.

III. Object, subject and methods of research

The purpose of the study is to develop water pollution control systems.

The object of the study is pollution control. **The subject** of the study is hardware for quality control of wastewater. According to the goal, the main tasks and methods of

solving the problem are: studying the basic characteristics of wastewater, developing a structural scheme of the hardware complex, developing algorithms for the modules of the complex, the calculation and selection of appropriate equipment. The wastewater pollution control system will identify and warn at an early stage about emergencies related to wastewater pollution. The main areas of application of this development are agriculture, mining, metallurgical and chemical industries, utilities.

IV. Work results

Considering the effects of water consumption from polluted reservoirs, it becomes obvious that the problem of water quality in reservoirs is quite urgent and needs a comprehensive solution. The level of control and purification of reservoirs to date is extremely low, which can lead to death. We offer a solution to the problem by controlling wastewater emissions.

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- the content of suspended particles does not exceed 60 mg / l;
- oil (condensate) content does not exceed 5 mg / l when extracted with ether;
- chromaticity - more than 20 units (platinum-cobalt scale);
- hydrogen index $\text{pH} = 6-9$ [5].

Having understood with the basic functional requirements to the created hardware complex, we proceed to the stages of development of algorithms of operation of the hardware complex and selection of the necessary constituent components of the complex. Before the stage of selection of the necessary components of the hardware complex, let us define the criteria of wastewater quality, on the basis of which we will pass to the stage of selection of components.

The hardware complex is based on basic physico-chemical indicators of wastewater quality, the amount of which can be changed at will. Such indicators include: temperature; hydrogen index pH ; turbidity.

Water temperature is an important factor influencing the physical, chemical, biological processes occurring in water bodies. Oxygen mode and intensity of self-purification processes depend on temperature. Temperature values are used to study thermal pollution, calculate the degree of water saturation with oxygen, various forms of alkalinity, the state of the carbonate-calcium system.

The requirements for the water quality of the reservoirs used for bathing, sports and recreation indicate that the summer water temperature as a result of wastewater run-off should not increase by more than 3 ° C compared to the average monthly temperature of the hottest month of the year over the last 10 years. In reservoirs of fishery purposes, it is assumed that the temperature of the water as a result of wastewater descent is not more than 5 ° C compared to the natural temperature [6].

The turbidity of natural waters is caused by the presence of impurities caused by insoluble or colloidal inorganic and organic substances of different origin. In accordance with the hygienic requirements for the quality of drinking water, the turbidity should not exceed 1.5 mg / dm³.

Water turbidity is determined turbidimetrically - the power of the beam passed through the water sample is measured. Turbidimetric method is used to determine reservoirs having variable composition and the form of fine particles. Without pre-filtration, turbidimetry samples will determine not only colloidal but also coarser particles.

Ph of water is one of the most important indicators of water quality. The concentration of hydrogen ions is of great importance for chemical and biological processes occurring in natural waters. The magnitude of ph depends on the development and vital activity of aquatic plants. Ph of water also affects the processes of transformation of various forms of biogenic elements, alters the toxicity of pollutants.

The content of hydrogen ions in natural waters is determined by the quantitative ratio of the concentrations of carbonic acid and its ions.

For the convenience of expressing the content of hydrogen ions, a value was introduced, which is the logarithm of the concentration of ions, taken with the inverted sign:

$$ph = - \lg [H +] \quad (1)$$

Ph changes are closely related to photosynthesis processes (due to CO₂ consumption by aquatic vegetation). The source of hydrogen ions are also humic acids present in soils. Hydrolysis of heavy metal salts plays a role when significant amounts of iron, aluminum, copper, and other sulfate sulfates get into the water.

The pH value in river waters is in the range of 6.5-8.5, in the atmospheric precipitation 4.6-6.1, in the swamps 5.5-6.0, in the marine waters 7.9-8.3. The concentration of hydrogen ions is prone to seasonal variations. In winter, the pH for most river waters is 6.8-7.4, in summer 7.4-8.2.

According to the requirements for the composition and properties of water of reservoirs of drinking water use points, water of water bodies in recreation areas, as well as water of fishery water bodies, the value of ph should not go beyond the range of 6.5-8.5 [7].

Having become acquainted with the basic goals and tasks of qualification work, we proceed to the implementation of algorithms and methods of implementation of the hardware complex in the next part of the work.

The hardware-programmable complex is used for the problems of prompt detection of water composition of the test solution. The composition of the water is determined by the levels of ph, turbidity and temperature. Because the composition of the waste fluid that comes in for processing fluctuates sharply over the course of not only a day, but also one hour, the use of hardware will help reduce test and data processing time.

Having analyzed the requirements for the security being created, the prerequisite is the operation of the device on remote sites. Today, there are a large number of technologies that allow the transmission of information over long distances. Data technologies are divided into wired and wireless.

Wired technologies include methods using copper and optical cables. The use of copper cables is characterized by high financial costs and low data rates. It is advisable to use such cables only in premises of a small type, otherwise the installation of protective equipment is required. Negative factors affecting copper cables are atmospheric phenomena in the form of rain, snow, sun, as well as the oxidation of conductors. All these factors lead to the rapid failure of appliances. Instead of using copper cables, fiber optic cables replace them. They are characterized by high reliability, data transfer speed and durability, but the cost of such cables remains high. High speed, reliability and security are the main advantages of using wired networks. Wired network security is achieved through a physical factor in order to connect to the network with the necessary physical access to the cable. The negative factors of using wired networks include the possibility of laying cables at short distances in cities where there is no difficulty in their installation, and the dependence of users on the location of the cable [8].

The most popular wireless data technologies are: Wi-Fi; Bluetooth; ZigBee; GPRS.

Wi-Fi is the IEEE 802.11 wireless standard. The advantages of this technology are the speed of data transfer (up to 11 Gb / s at the moment), ease of use - in places where no cable can be used wireless networks, mobility - users do not depend on the location of the Wi-Fi router within the range of Wi -Fi, malware - radiation from devices is much less than from a mobile phone.

Disadvantages include range and security, and can be easily cracked by criminals. The 2.4 GHz band is also a disadvantage, as it may interfere with the use of Bluetooth devices and even microwave ovens. For the most part, the stated speed of Wi-Fi networks is not true, since the speed of connection to the access point is distributed among all clients, the speed depends on the number of antennas used, obstacles, distance to the access point [9].

Bluetooth is a wireless data technology, up to 10 meters away. The advantages of using Bluetooth technology include convenience, speed of data acquisition, versatility of use. The disadvantages include the range, interference reduction, interference with other devices.

ZigBee is a personal wireless network, created in 2003. Unlike previous technologies, it consumes less power and runs at low speed, well suited for controlling wireless sensors, meters, and other equipment. ZigBee has a range of 10 to 100 meters and a bit rate of 250 Kbps. The advantages of this technology are fault tolerance - even when interference occurs, the data will be delivered to the destination, reduced power swelling -

the presence of such a factor provides long-term work from autonomous power sources, the availability of sleep mode, the ability to change the routing algorithm, the ability to use channels of several frequency bands, relatively low frequency bands. cost, cryptographic protection in data transmission.

GSM is the international standard for high-quality mobile digital communication through public key encryption. GSM technology was founded in 1987 and adopted as the European standard for digital mobile technology. The key to technology success is the ability to support Internet and SMS services. GSM networks operate in the 900 MHz or 1800 MHz frequency range. The technology allows to transmit voice information, to transmit data in synchronous and asynchronous modes, to send short text SMS messages, to send multimedia MMS messages [10].

GPRS is a packet data system that operates similarly to the Internet. When transmitting data, the latter are broken down into separate packets, then delivered to the recipient and combined into one unit. The block diagram of GPRS is shown in Figure 1. Packages can be delivered separately in any way. Packages are in the form of IP, so it is possible to use any standard transport and application layer protocols used on the Internet (TCP, UDP, HTTP, HTTPS, SSL, POP3, XMPP). Also, when using GPRS, the mobile phone acts as an external network client and is assigned an IP address (fixed or dynamic). GPRS technology is an add-on to GSM technology and allows data to be transmitted at a higher rate, unlike GSM, where the maximum data rate is 14.4 Kbps, GPRS transmission speed can theoretically reach 171.2 Kbps. GPRS consists of two main blocks - SGSN (GPRS support node) and GGSN (GPRS gateway node). SGSN is the brain of the system, it is a GSM network switch. There may be several SGSN nodes in the system, each of which is responsible for its area of the network. The SGSN node can support up to 2000 packets per second, while controlling up to 10,000 users online. The main tasks of SGSN are routing packet data streams between MS and GGSN, providing subscriber authentication, message encryption. GGSN is the gateway between the network (more precisely, its part for GPRS data transmission) and external information backbones (Internet, corporate intranet networks, other GPRS systems). The main task of GGSN, therefore, is to route data from and to the subscriber via SGSN. GGSN's secondary functions are data addressing, dynamic IP issuance, and tracking of external network and subscriber information (including service billing). Another component of the GPRS system is the PCU, a packet control device. The PCU connects to the BSC base station controller and is responsible for directing data traffic directly from the BSC to the SGSN [11].

The advantages of the GSM standard are the small size of the devices, the good quality of communication, the ability to support a large number of simultaneous connections, the low level of industrial interference, the protection of information during data transmission, widespread distribution, a large number of users. The GSM standard is the most widespread in the world, with an annual increase of 1 million users. Today, the number of users reaches more than 4.4 billion people. However, GSM technology is not perfect and like any other technology it has its drawbacks. The disadvantages include the low data rate and the ability to transfer data no more than 120 kilometers from the nearest base station. Despite the drawbacks of the GSM system, it is quite popular and easy to use when connecting equipment in remote areas, in cities where cable routing is impossible or

inexpedient and expensive. Such systems are characterized by low speeds, but they are sufficient to transmit small amounts of information.

Considering the possible data transfer options and requirements for the security being created, we can conclude that wireless data technology is needed since the device is always located in remote areas of the data center and the number of devices used may vary. In this case, the use of leading technologies is an inexpedient and expensive solution for the long-distance cable routing in physically unfavorable conditions. Therefore, it was decided to equip the GSM GPRS devices with a mobile communication module. Technology covers about 99% of Ukraine's area, so there are no problems with long-distance data transmission. The speed of GPRS technology is enough to send small amounts of information, namely sensors from the sensors, to the data center for processing.

Summing up, we have all the necessary components to create a hardware complex to control the composition of hydrogen samples. The necessary components of the complex are: microcontroller; GSM GPRS module; ph sensor; turbidity sensor; temperature sensor.

The general algorithm of system operation is as follows: sequential collection of data from sensors, preparation of data for sending, sending of data to the server. Users are able to view real-time data using the website software.

The device consists of sensors of temperature, turbidity, acidity and SIM module. The board is powered by a USB cable. The ds18b20 temperature sensor is connected to the board via external power, 3 wires are used: the sensor's ground (GND) is connected to the board's (GND) ground, the Vdd is connected to the 5V output of the board, Data is to the seventh digital pin. Because the sensor uses a 1-Wire interface, it is necessary to include a 4.7 ohm resistor between the power line and the data line. The transmission of any information is possible only by issuing a low level in the data line, ie, shorting it to a common wire (GND), and in high logical level the line will return itself, due to the presence of an external resistor 4.7 kOhm.

The turbidity sensor is connected to the board as follows: GND line to board ground (GND), Data line to analog input A0 board, power line to 5V board output. The sensor also has a gain card that has an analog-to-digital switch. The switch works in both analogue mode - measuring the turbidity level of the test environment by changing the output voltage level and in digital mode - a logic level "1" appears on the output when the turbidity reaches the limit value set by the built-in potentiometer.

The ph level sensor is connected in the same way: GND line to the board ground (GND), Data line to the analog input A1 of the board, power line to 5V output of the board. The sensor also has a PH2.0 interface board, which houses a gain control potentiometer and a power LED. When the sensor is connected to the Arduino board, a blue LED lights up on the sensor board. The sensor comes with a fluid that has a known ph level of seven. After connecting the sensor, it is necessary to check its values, if the obtained values of the liquid of known acidity differ, the programmed way should be set the shift value. It is also possible to adjust the sensor performance using a built-in potentiometer.

The SIM800l wireless data module requires an additional power source. Since the module requires a current consumption of 2A and the Arduino card is not capable of supplying such a current level, it is advisable to use an external source with an additional

DC voltage converter. The main condition for such a connection is the common ground for all elements of the system, so the earth converter line has common contact with the SIM8001 ground line and the Arduino board. The TX data line of the SIM8001 module is directly connected to the Arduino board, and the RX data line is connected to the board via a voltage divider, two 10kΩ resistors.

As a result of connecting all the components, we get the scheme shown in Figure 1, for simplicity of connection uses a breadboard.

The figure shows the unit in a single housing. Inside are an Arduino board, a DC-DC 5V voltage drop, a circuit board for all components, a sensor board, and a sim module.

The main task of the hardware complex is to measure the level of water pollution, but in addition to the basic tasks there are additional, less-significant, which are responsible for the location and identification of the device. Having summed up all the tasks, we will list them together:

- obtaining the device identification number;
- obtaining the coordinates of the location of the device;
- obtaining indicators from the temperature sensor;
- obtaining indicators from the turbidity sensor;
- obtaining indicators from the ph level sensor;
- sending metrics to the server.

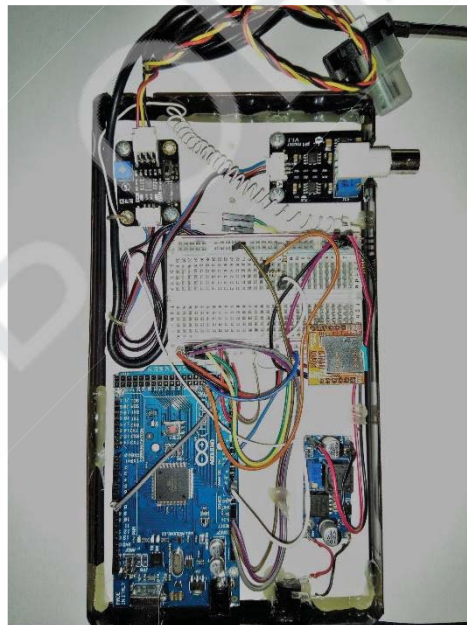


Figure 1 - Connecting existing components to an Arduino board

Data from a developed device can be viewed by a user on a developed website. The site contains the following pages: current data; archive; archive of data in the form of graphs.

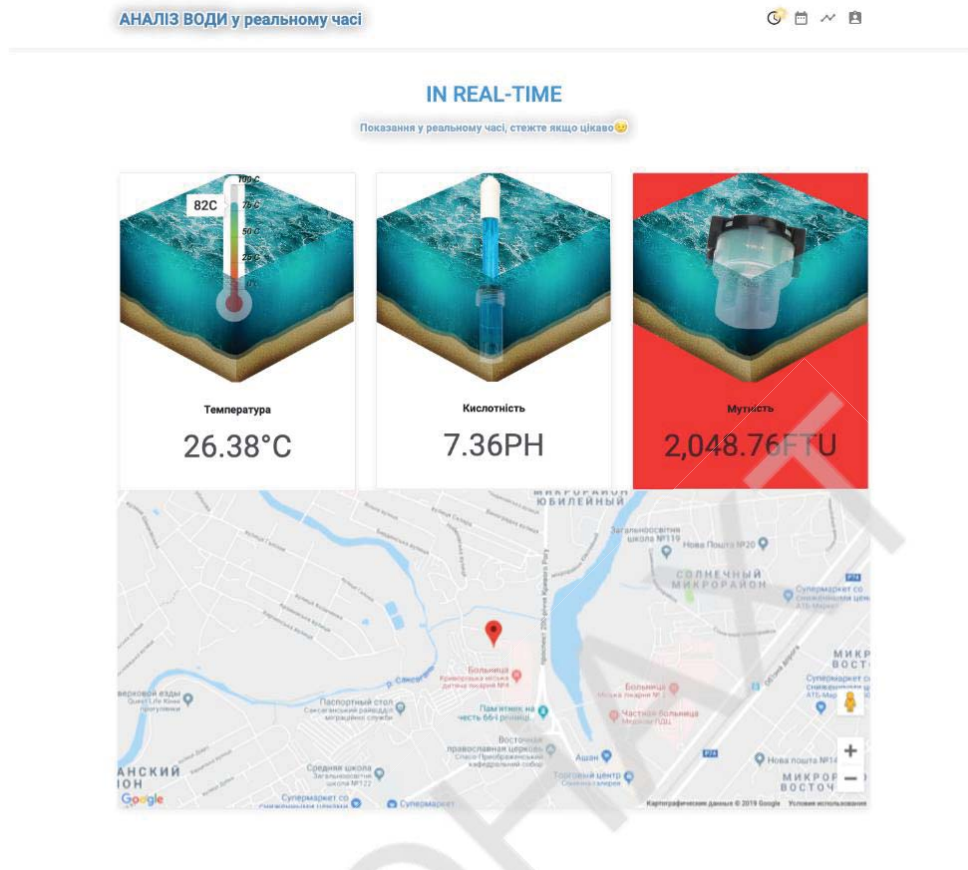


Figure 2 - Website developed

Conclusions

As a result of the work done, a wastewater quality control system was created. The following tasks were performed during system creation:

- literary sources on the topic of pollution of reservoirs were elaborated, important aspects of quality control of reservoirs were identified;
- requirements for water quality criteria are analyzed;
- analogue products are analyzed;
- algorithms of the hardware complex operation were developed;
- the product has been commissioned.

The device allows to control the operation of treatment plants and emissions of pollutants into the reservoir. The practical importance of the device lies in the timely prevention and cessation of contamination of water bodies with untreated and insufficiently treated wastewater.

The main advantage of the device is the ability to work on remote objects, the results are stored on a web server and available for viewing at any time. The advantage of the device is its cost and its small size. Such parameters make it available for own use on the farm, in agriculture, in utilities and industrial enterprises. The disadvantages are the

quality of components, compared to the more expensive industrial analog devices, it is lower and needs improvement.

The device was created as a cheaper possible variant - a prototype of already existing devices, and in the future it is possible to improve the system on the basis of already developed components.

Test results indicate that each component of the instrument is serviceable and ready for use. The next step is the introduction of the appliance in every field of use, starting from one's own farm and ending with industrial enterprises.

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