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Research Article

IMPROVEMENT OF THE GROUNDWATER MONITORING SYSTEM IN REAL TIME

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ABSTRACT
This article describes the issue of improving the groundwater monitoring system in real time. As a result of methodological and software improvement of existing monitoring systems, real-time online monitoring of underground water was created, and effective methods of measuring, transmitting, storing and analyzing underground water regime parameters were developed using the capabilities of telecommunication technologies. As a result of the creation of a rapid information array of the underground water monitoring system, a database and a web interface software for visualizing it have been developed. As a result of the improvement of the existing monitoring system, real-time groundwater monitoring has been made possible.

Keywords: *real-time, groundwater, monitoring system, geoinformation technology, device, database, automated and web interface*

INTRODUCTION
At present, comprehensive measures aimed at the control and regulation of the rational use of underground water reserves, and the fundamental improvement of the conditions of providing the population with quality drinking water are being implemented. One of the urgent issues is the development of modern methods of groundwater monitoring to meet the population's demands for high-quality drinking water, rapid analysis of the state of the groundwater regime, and, in necessary cases, the creation of effective water resources management systems [Djumanov at al., 2021; Amjad and Ahemed, 2019]. Therefore, issues related to improving automated monitoring systems, increasing the speed of monitoring processes based on automatic measurement technologies, and ensuring their operation online are becoming important in conducting effective monitoring of the state of underground water.
Comprehensive scientific research aimed at the development of monitoring systems for the study of groundwater regimes in the world based on modern geoinformation technologies, monitoring of groundwater parameters with the help of automated monitoring devices and tools, and the formation of a digital database of the state of hydrogeological objects is carried out in the world's leading scientific institutions, including: the USA, It is conducted in Germany, Holland, Canada, Netherlands, India, Russia, Japan, China, Kazakhstan and Uzbekistan [Priya and Sailusha, 2017; Djumanov, 2016].
However, at the same time, the increasing influence of natural and man-made factors on groundwater, the increasing demand for groundwater, and the issues of their protection and management remain relevant. In this regard, the creation of a monitoring system based on geoinformation and telecommunication technologies for the detection and analysis of sudden changes in the regime parameters of underground waters, including the development of effective methods of applying geoinformation technologies in groundwater monitoring, improving the methodological and software support of the monitoring system, developing algorithms of the online monitoring system output, improvement of the database, and analysis of data reflecting the state of hydrogeological objects are important tasks.

MATERIALS AND METHODS

At present, in the effective monitoring system of underground water, most automated underground water regime information measuring technologies are widely used [Alekseeva et al., 2013]. The lack of groundwater monitoring data makes scientifically based assessment and management of groundwater resources difficult. Therefore, regular monitoring is required to determine the condition of groundwater and its quality indicators. This in turn raises the issue of improving real-time groundwater monitoring systems, recognizing the need for systematic groundwater data collection.

In this place, a number of scientific and practical research works have been carried out in our Republic on the basis of automatic monitoring of underground water conditions, determination of their regime parameters, formation of a database. As a result of practical research work, high results were achieved, but as a result of observing the work activities of these devices, the need to improve some aspects was observed [Khushvaktov et al., 2020; Khabibullaev et al., 2021].

In particular, comprehensive measures related to the monitoring of groundwater resources, methodological and software improvement of existing monitoring systems, and effective monitoring of groundwater resources were carried out. According to the results of scientific research, the existing system has been improved by implementing real-time online groundwater monitoring management capabilities. It is possible to monitor the monitoring results of groundwater regime (groundwater level, temperature and electrical conductivity) parameters online in real time on the central control computer.

In order to increase the efficiency of the monitoring system, the monitoring device was improved based on the use of economical technologies. The rational organization of the processes of measuring, transmitting and receiving initial data from monitoring devices largely determines the efficiency of data processing. The core of improving groundwater monitoring is the use of modern telecommunication and geoinformation technologies that allow for the implementation of effective methods [Silich et al., 2013], namely:

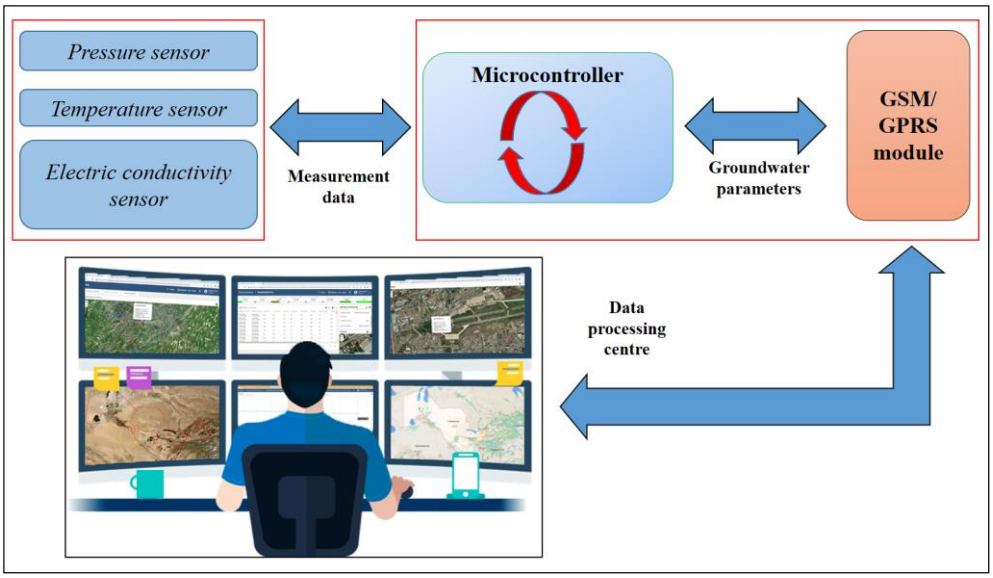
- development of effective methods of measurement, transmission and reception of groundwater regime data using the possibilities of telecommunication technologies;
- development of effective methods of visual representation and analysis of the state of groundwater regime parameters using a database.

In order to increase the effectiveness of underground water monitoring through fundamentally new management methods, work on improving the monitoring system was carried out based on geoinformation technologies. These methods are based on the results of the analysis of the state of groundwater, as well as reducing the time spent on processing various data, using modern telecommunications, geo-information technologies and software tools for decision-making.

Based on a number of fundamental organizational and technological aspects of the development of the groundwater regime parameters monitoring system, attention was paid to the following methods in the formation of its implementation program [Mardiyev, 2021; Beldeubaeva and Rakhmetullina, 2016]:

- designing and creating a structure of real-time monitoring of groundwater;
- effective use of available modern information and communication technologies and technical resources to create and implement automated monitoring of underground water;
- to determine the location points of the devices installed in the monitoring wells and to create methods for analyzing the parameters of the underground water regime;
- creating an interface for online groundwater monitoring system and providing convenient opportunities for users.

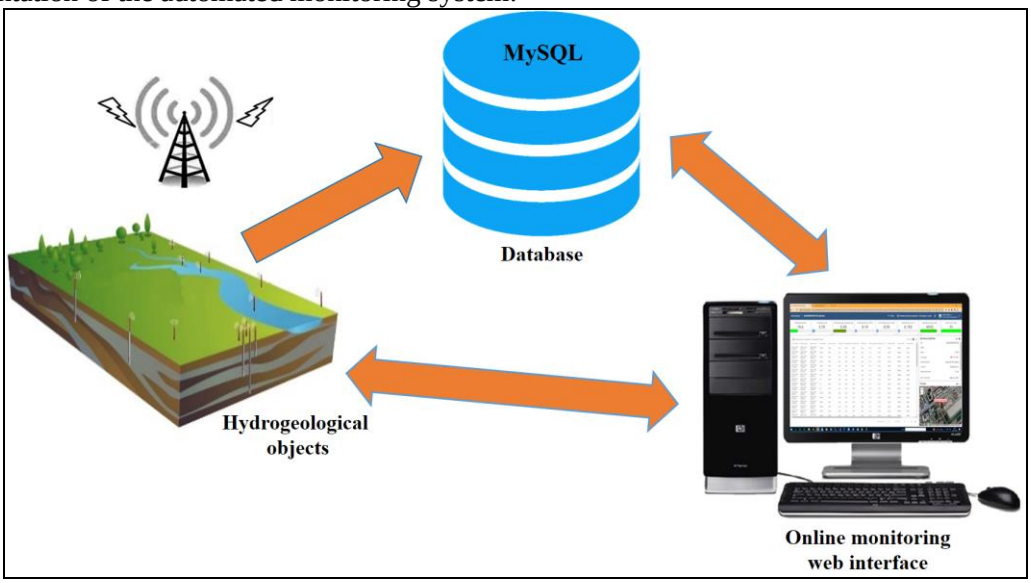
In order to implement the above methods, initial results were achieved in scientific and practical research works aimed at improving the monitoring system of underground water regime parameters, which provides the opportunity to determine the condition of hydrogeological objects. Taking into account these aspects, the software for initial measurement, remote transmission and reception of groundwater regime data was developed. According to the results of the improvement, the online monitoring system of the regime parameters of underground water is implemented according to the following structure (Picture 1).



Picture 1. Structure of groundwater monitoring system

As shown in this structure, it is possible to implement online monitoring of groundwater regime parameters in hydrogeological objects from the data processing center. The structural structure of the underground water monitoring system and its several parts based on the principle of modules, which are grouped into a single database, participate in the performance of tasks. Assessment of changes in groundwater regime parameters is carried out by analyzing the sequential monitoring of the studied indicators [Zlobina et all., 2017].

When developing a monitoring system, it is important to develop a process for the formation of a groundwater database, because it ensures the effectiveness of an automated monitoring system. The database of the monitoring system allows you to combine the ability to store data sets inherent in the relational model and increase the speed of query execution. The core of the system is an integrated database located in the control center. The data acquisition process is formed directly in the integrated database created through the web interface of the automated monitoring system. Following picture 2 shows the structure showing the structure and composition of the processes, objects, tools of the implementation of the automated monitoring system.

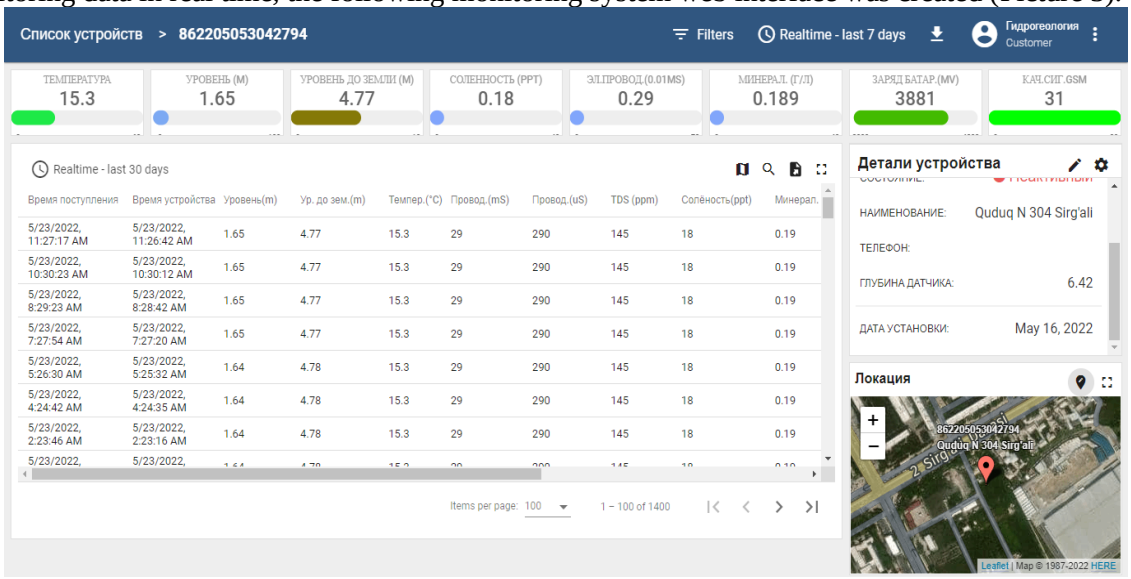


Picture 2. Developing structure of the database

On the basis of the structure that shows the process of formation of the database, the structure and content of the objects, tools, the groundwater database was developed using the MySQL database management system. As a result, it was possible to analyze the regime parameters of underground water and the state of hydrogeological objects using the database through the web interface software. A web interface is software that provides a user interface for communicating with devices, receiving data, or sending requests using the HTTP protocol [Loskutnikov et al., 2011].
The online groundwater monitoring system is a modern high-performance tool to support strategic and rapid decision-making, closely supporting users for analysis and management decisions based on the rapid provision of necessary groundwater information. This, in turn, provides an opportunity for timely detection, evaluation, prevention of negative consequences and monitoring of quality indicators.

RESULTS AND DISCUSSION

Automated underground water monitoring system is an information system designed to monitor changes in the field of monitoring activities, measure, transmit, store, process and use initial data. That is, in this, opportunities such as remote online monitoring of groundwater regime parameters, sending management requests were achieved [Khabibullaev et. al., 2022]. The monitoring system designed to perform management functions consists of a set of software and information tools integrated into a single system for the purpose of measuring, transmitting, storing, processing and presenting initial data.
The web interface software of the monitoring system has the ability to monitor the operational status of the devices, groundwater regime parameters, and change the device settings (name, measurement time, sending time, etc.) through the results obtained from the devices installed in the monitoring wells. It is possible to use the capabilities of the modules, such as determining the geographical locations of the devices installed in the monitoring wells, displaying graphical views (daily, monthly and yearly) based on the tabular data collected for each object. In order to improve the efficiency of obtaining groundwater monitoring data in real time, the following monitoring system web interface was created (Picture 3).



Picture 3. Web interface of groundwater monitoring system

Tasks such as rapid data analysis can be performed online through this web interface software. In rapid data analysis - online monitoring data processing technology, multidimensional data collection, storage, and analysis methods are used to support decision-making processes. Representation of the obtained results in graphical forms creates opportunities for rapid analysis of regime parameters of underground waters.
Through the web interface software, it is possible to implement real-time rapid monitoring of groundwater regime parameters in hydrogeological monitoring wells. In such conditions, a number of analysis and research works are carried out on the basis of data obtained using remote online monitoring of groundwater in real time, management technologies [Djumanov et al., 2021].

CONCLUSION

The economic effectiveness of the monitoring system consists in the formation of a system of harmonious regulation of the state of underground water in hydrogeological objects and the maximum amount of information on the state of underground water based on the use of software products. On the basis of the improved monitoring system, the regime parameters of underground water are determined in real time. This, in turn, created opportunities to evaluate hydrodynamic and hydrochemical (electrical conductivity, mineralization) indicators of underground waters. By using these opportunities, the time spent, manpower and economic costs are saved, and the quality, speed and efficiency of the obtained results are increased.

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