International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2025 Vol. 15, pp. 39-44/Erkin and Dilnavoz
Research Article

DETERMINATION OF TOTAL MINERALIZATION OF GROUNDWATERS USING AUTOMATED SYSTEMS AND THEIR SIGNIFICANCE IN MEDICAL HYDROGEOLOGY

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ABSTRACT
This article discusses the role of automated measurement systems in determining the total mineralization of groundwater and their importance in medical hydrogeology. Methods for monitoring water composition in real time using modern technologies are analyzed and the advantages of automated devices are considered. The results of the study show that it provides high accuracy and efficiency in determining the mineral composition of water. Also, this approach serves to study the content of heavy metals that affect human health in medical hydrogeology, their control, and environmental sustainability.

Keywords*: Groundwater, Total Mineralization, Automated Measurement Systems, Hydrogeological Monitoring, Medical Hydrogeology, Mineral Waters, Water Quality, Real-Time Monitoring, Sensor Technologies, Environmental Sustainability*

INTRODUCTION

Presently, a lot of scientific researches on the provision of drinking water to the population are being carried out, in particular such as assessment of underground water resources and their rational use, determination of the laws of water exchange in the regional drinking water field based on automated measurement systems, improvement of automated monitoring methods and the use of high-tech software tools, the methods of creating automated information system. In this regard, it is considered urgent to develop technical solutions based on information systems, automated measurement methods and their algorithms, as well as hardware and software tools in the study of hydrogeological characteristics of underground waters (Djumanov, 2016).

Groundwater is an important natural resource for human life and the environment. Its quality and composition depend on various natural and anthropogenic factors, and in particular, the level of total mineralization determines the possibility of using water for drinking and medical purposes. Analysis of the mineral composition is important for determining the impact of water on human health and its effective use in medical hydrogeological research.

Since traditional analysis methods are usually time-consuming and limit the possibilities of continuous monitoring, the need for modern automated measurement systems is increasing. These systems allow real-time monitoring of groundwater levels, temperatures and total mineralization. Data obtained using IoT technologies, artificial intelligence and sensor systems play an important role in managing water resources, ensuring their ecological sustainability and developing medical hydrogeological research.

This article analyzes the principles of determining the total mineralization of groundwater using automated systems, their importance in medical hydrogeology, and their practical application. This approach allows for improving the monitoring process of mineral waters and scientifically assessing health-improving sources.

Currently, foreign countries are using automated methods of measuring groundwater regime parameters in practice (Djumanov, 2011).

In the ongoing research work, experimental design work consisting of ultrasonic and radio wave sensors is being carried out to further improve the accuracy level and efficiency of the device for measuring the regime parameters of underground waters (Djumanov *et. al.*, 2022).
It is important to analyze the geological and hydrogeological condition of the area in order to introduce the automated measuring device in the large objects of the national economy.
In recent decades, the increase in usage of groundwater resources for human and agricultural purposes has led to a significant drop in the groundwater level in most countries, so that the regional decline of groundwater resources has become a global issue. Soil structure and surface water quality in a region can determine the quality and composition of groundwater (Jahanshahi et al. 2014). Groundwater quality depends on the quality of recharged water, atmospheric precipitation, inland surface water and subsurface geochemical processes. Temporal changes in the origin and constitution of the recharged water, hydrologic and human factors may cause periodic changes in groundwater quality (Amiri et al. 2014). Once groundwater is pol¬luted, it is hard to stop the pollution and human health is closely related with the groundwater quality.

MATERIALS AND METHODS

Another area of research is public health in connection with the production activities of exploration and mining enterprises. For example, silicosis, asbestosis, anthracis are diseases caused by exposure to quartz, asbestos, and coal dust. This also includes the problem of natural radioactivity and radon safety. The potential hazard of chemical substances depends on their physical and chemical state. Understanding the mechanisms and consequences of the impact of chemical elements and compounds on the environment and public health makes it possible to safely extract and process mineral raw materials, minimize the impact of toxic elements and compounds on human health. According to the results of research conducted in recent years, the causes have been identified, the mechanisms and conditions for the concentration of elements and compounds - toxic substances - in the terrestrial atmosphere, hydrosphere, and atmosphere have been determined. The consequences of their impact on living systems have been determined. Geological models have been developed to form various medical and environmental conditions. Modern information technologies are increasingly being used, and geoinformation technology (GIT) projects are being developed to conduct environmental monitoring in geologically hazardous areas (Wolfson *et. al.*, 2010).
Due to the deterioration of the quality of surface water sources, the use of groundwater in the water supply system for the population is becoming increasingly important. At the same time, perceptions of the widespread high quality of groundwater are changing. Analysis of global and local literature allows us to identify the causes and causes of negative changes in nature (Elpiner, 2016).
This study used modern automated measurement systems and hydrogeological monitoring technologies to determine the total mineralization of groundwater. The study included the following stages:
- mineral water sources, drinking water deposits and hydrogeological monitoring points were selected as the study area;
- water samples were taken at different depths of groundwater and their quality characteristics were assessed.
The following automated systems were used to determine the total mineralization, level and temperature of groundwater:
- multifunctional hydrochemical sensors (electrochemical and optical sensors);
- salinity and electrical conductivity meters (EC-meters);
- IoT-based monitoring systems (possibility of real-time data transmission);
- data visualization and analysis through GIS (Geoinformatics Systems).
- automatic recording of water level, temperature and total mineralization at specified intervals based on sensor systems.

- Data collection and analysis: Data from sensors were transmitted to a cloud server or **central database.
- Comparison with laboratory tests: Sensor measurement results were compared with traditional laboratory analyses and their accuracy was assessed.
- Statistical analysis: The obtained data were analyzed using correlation and regression methods.
- Medical hydrogeological assessment: The impact of water composition on human health was assessed based on scientific articles and sanitary standards.

Using these methods, the possibilities of monitoring the total mineralization of groundwater through automated systems were considered, and their significance in medical hydrogeology was studied.

The set of physical, chemical and biological indicators that can be used to describe the hydrogeological properties of groundwater is divided into the following groups (Khushvaktov *et. al.,* 2019):

- hydro regime characteristics - water level, water level slope, water volume, etc.;
- characteristics of the underground water temperature regime - water temperature change, amplitude, heat flow, etc.;
- characteristics of the hydro chemical regime - water mineralization (salinity), salt content (content of individual salt ions), concentration of organic, biogenic, polluting substances, etc.

Based on the above, it is possible to determine the general level of mineralization of groundwater, ionic strength, hardness, as well as the content of sulfate ions in groundwater by the value of electrical conductivity (Nazirova, 2022).

In continuous, long-term, continuous, real-time monitoring of water level, a hydrostatic pressure sensor (also called a hydrostatic level gauge) used in determining the water level is is the main technology and measurement principle of the sensor.

Hydrogeological studies are an important part of human scientific and economic activity. They are carried out as separate works or together with engineering-geological studies. For example, in the design of any structure, it is important to study the characteristics of the soil, the degree of occurrence of groundwater, their volume and the direction of underground flows. Hydrogeological studies help to equip deep wells for water extraction. Information about underground water reserves, their relationship with rocks and soils, as well as water properties (porosity, moisture capacity, capillarity, etc.) is of great importance in water supply, hydraulic engineering, road and general construction. is important.

Groundwater level measurement is critical for predicting long-term trends in water table decline, saltwater intrusion, seasonal changes, aquifer recharge, surface aquifer conservation and restoration, and drinking water status.

The researched automated measurement methods also help to solve the following issues:

- Conducting complex hydrogeological studies and observations during experimental filtration works;
- Carrying out regular monitoring of the condition of the subsoil during development of cluster pumps, extraction wells;
- Conducting hydrogeological work in remote and hard-to-reach areas;
- Measuring the temperature of underground water at a certain depth in research, monitoring, mode wells, piezometers of production wells;
- Monitoring water flows at measuring stations;
- Hydrodynamic monitoring of seismic risk;
- Monitoring the effectiveness of drainage measures in mineral deposits;
- Balanced management of drinking water resources;
- Monitoring of aquifers;
- Warning about the possibility of natural disasters and floods.

The device under study reliably measures the required parameters due to its long and durable battery life.

Based on the information and technical support of conducting hydrosphere monitoring on observation wells, it is important to replace the laborious measurement process by manual labor with automated sensors in the collection of observation data at hydrogeological stations in our republic.

RESULTS AND DISCUSSION

It is vital to use the modern information communication systems, i.e. a general device-software complex in hydrogeological and engineering geological studies conducted with the purpose to reveal the elements and balance of the hydrogeological regime in the process of observational monitoring of groundwater and in solving various issues of the national economy (Djumanov *et al.*, 2022).

Method of hydrodynamic analysis of groundwater regime. It is carried out on the basis of applying the theory of unstable movement of groundwater in the calculation of the main elements of their balance and observing the regime of groundwater. The method takes into account the hydrogeological situation in all respects, allows to estimate the infiltration of precipitation, the reach of irrigation water to the groundwater level, the consumption of total evaporation and underground flow, as well as the necessary hydrogeological indicators. All this information is directly used in the preparation of forecasts of changes in the groundwater regime under the influence of human socio-economic activities. The method is particularly effective and cost-effective in the practice of hydrogeological research, because the main source of observation data on the water level regime is obtained from special observation wells located in typical balance zones (flow elements).

A software complex has been created to help install this device in monitoring wells, which consists of menus such as settings, data retrieval from memory and setting the data transfer interval, as well as taking measurements (Figure 1).

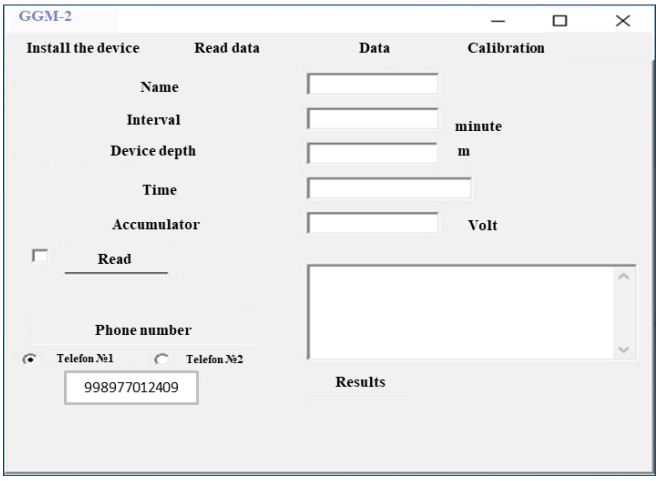

Figure 1. Interface of the software complex that helps to install the automated measurement device in the monitoring wells.

Based on the automated measuring device, data on the level, temperature and electrical conductivity of groundwater were obtained from the monitoring wells with a two-hour interval (Figure 2). The data obtained from the device consists of the following components:

- 64з - the name of the device installed in the monitoring well;
- 08/12/2022 20:30 - the date and time of the sensor measurement;
- Level= 9.807m - the water level in the monitoring well relative to the ground;
- Temp=20.5°C - water temperature;
- EC = 1236 µSm/cm - the electrical conductivity of water;
- Uak= 3.7V - the power of the power source in the device.

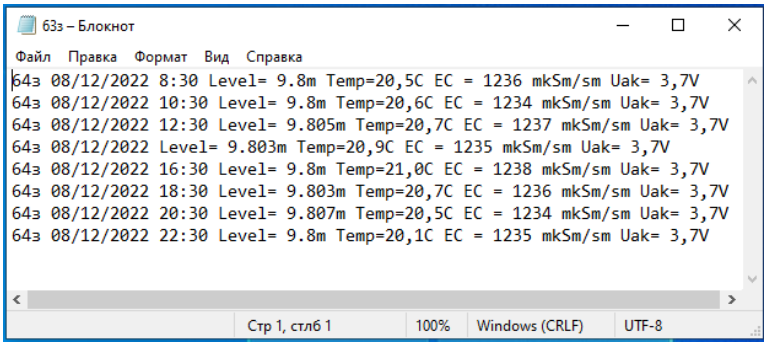

Figure 2. Data from an automated measuring device.

The values of the electrical conductivity of groundwater measured in the following ranges using an automated measuring device are converted into total mineralization based on the "Calculation of Total Mineralization" application software package as follows:
0.02-0.5 g/l in the range of 50-1032 µS/cm;
0.51-1 g/l in the range of 1033-2090 µS/cm;
1.01-3 g/l in the range of 2091-5705 µS/cm;
3.01-5 g/l in the range of 5706-9195 µS/cm;
5.01-5.5 g/l in the range of 9196-9999 µS/cm.
Results of 10,000 µS/cm and above are indicated in the window of the application software as "highly mineralized".
One of the most important indicators of water quality is the total mineralization value, which is usually determined gravimetrically from the dry residue. Using the data of chemical analysis on the content of chloride, bicarbonate, sulfate ions, and conversion factors, it is possible to calculate the total mineralization value (g/l) of the water under study (Gaev A.Ya. 2001).
Regular measurements are important for continuous monitoring of the state and quality of groundwater (Dzhumanov *et. al.*, 2023).
Simple measurements of groundwater include:

- measurement of the dynamic water level in the well and water consumption;
- determination of organoleptic indicators (water temperature, color, turbidity);
- determination of chemical indicators (hydrogen index pH, total water hardness, concentration of iron, nitrates, sulfites, chlorides, fluorides);
- determination of indicators characteristic of groundwater (concentration of hydrogen sulfide, beryllium, boron, molybdenum, arsenic, lead, strontium, zinc).

Research was carried out to study the content of heavy metals in groundwater using the total mineralization value obtained using automated measuring devices.
The above-mentioned EC = 1236 µS/cm electrical conductivity value belongs to the range of 1033-2090 µS/cm, and the total mineralization of water is 0.8 gr/l. Therefore, water samples are taken from the observation well for laboratory analysis and the pH, anions and cations content are checked. As a result, it is possible to determine the amount of heavy metals in water and assess their impact on human health.

Conclusion

This study investigated the principles of determining the total mineralization of groundwater using automated measurement systems and assessed their importance in medical hydrogeology. Automated measurement systems provide high accuracy and efficiency. Remote monitoring of groundwater level, temperature and total mineralization using sensor technologies is faster and more reliable than traditional laboratory methods, and allows for continuous monitoring. As a result, it is possible to continuously monitor the quality of groundwater and assess the medical hydrogeological state.

Based on automated measuring devices, the ability to identify water sources that do not meet hygienic requirements increases. Digital technologies serve as an important tool in reducing the risk of groundwater pollution and organizing their sustainable management. These results show that the use of automated measuring systems is of great importance for the effective organization of hydrogeological monitoring, water resources management, and the development of medical hydrogeological research. Therefore, it is recommended to further develop and implement such technologies.
In addition, the amount of some heavy metals in groundwater exceeding the permissible limits can cause significant harm to human health. This research also serves to some extent to develop recommendations for monitoring water quality and informing the public about the need to use quality drinking water.

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