Integrated Identification and Efficient Use of Biodiversity in Mountainous Regions

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Abstract. The article studies the comprehensive identification and efficient use of biodiversity (geothermal sources) in mountainous regions. Discussion of the ways to solve the most acute problems affecting mountainous regions with complex relief has always been on the agenda as a topical issue. The purpose of the presented work is to determine the quantitative, qualitative and thermodynamic parameters of geothermal sources in these territories, as well as the spatial structure of the foci of formation of their migration routes. Conducting a comprehensive assessment of the biodiversity of deforested mountainous regions substantiates the need to ensure the protection of these unique ecosystems. The issue of determining the direction of the integrated use of geothermal resources is studied not only by its structure and characteristics, but also by the level of development of complex technological processes for the extraction and processing of hydromineral raw materials and the technology of thermal energy processes. Using a number of analytical research methods (hydrogeological, geochemical, geophysical, isotope, computer (mathematical) modeling and others) to solve these problems, we determine the foci of formation of reservoir conditions in individual horizons, migration routes, as well as quantitative and qualitative parameters of thermal waters. The following issues were studied: hydrogeological research methods will help to identify the development zone of the intensive circulation aquifer (active water exchange) and the base of the development zone of the deep underground flow aquifer (impeded exchange) in the underground hydrosphere zones, and to assess their hydrodynamic and hydrothermal conditions and parameters. Based on the data from drilled exploratory oil wells, the conditions for the formation of thermal water layers in various hydrogeological structures will be determined; hydrochemical research methods will be aimed at assessing the macro- and microcomponent composition and radiation background of thermal waters at various intervals of migration routes by determining various indicators at different depths of their formation (based on the petrochemical structure of the geological part); isotopic studies of the gas composition of thermal waters will help to identify their genesis and use them as a marker when determining the points of formation; computer modeling of the underground hydrosphere of a representative object was carried out using mathematical programs.

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1 Introduction

As an alternative energy source, the determined energy potential of thermal water generation centers can be used in various industries, agriculture, utilities, as well as balneology, sanatorium and other fields.

The results will be widely used in industrial and agricultural production, utilities, medicine and other areas of the republic's economy.

As a result of comprehensive research, the spatial structure of quantitative and qualitative parameters of the thermal and mineral waters of the studied area, their thermodynamic parameters and the formation of the focus of migration routes was revealed. The obtained results are the basis for the development of the technology of using thermal energy of the source of thermal waters in various sectors of the national economy of this region [1-5].

Identification and use of alternative energy sources is currently one of the urgent problems in the world, including in the Republic of Azerbaijan. Thermal water is one of the alternative energy sources and is widely developed in the republic. During the day, their temperature on the surface varies between 32÷74°C. The research of the gas content of the thermal and mineral waters of the Republic shows that their gas content differs from the gas content of the Lesser Caucasus sources (mainly CO2), and most of them contain hydrogen sulfide (H_2S) and methane.

The problem of the formation of thermal waters is complex and multifaceted, not only theoretical, but also of important practical importance. The main role in the formation and distribution of thermal water deposits is played by structural features that are important in the formation of heat centers and energy potential in individual local areas [6, 7]. Thermal waters are an underground source of energy with great natural potential. The fact of wide spread of thermal waters has been confirmed in the territory of the Republic of Azerbaijan.

In these natural sources, the water temperature is 28-52°C, the flow rate is 0.1-2.0 l/s, rarely 5.0-8.0 l/s, and the degree of mineralization varies from 0.4 to 5.8 g/l. The gas composition of all sources is characterized by methane-nitrogen-hydrogen-sulfide mixture in the Greater Caucasus and Talysh, and mainly by carbon dioxide within the Lesser Caucasus. The chemical composition of water is hydrocarbon-sulphate-sodium-calcium-magnesium, in most cases sodium-calcium chloride is less common [8, 10].

Thermal water sheets exert varying degrees of pressure, but under natural conditions they do not spread over the sun's surface. Mainly oil with defined parameters was discovered by exploratory wells. The thermal waters here have been identified from a depth of 200-250 meters to 8,200 meters (the bottom of the Saatli deepest well) [9]. Water pressure towers, piezometric levels above the roof of the horizon are placed in wells from 2137 m to +40 m above the ground surface. The mineralization of the imagined water varies from 0.5 g/l to 220 g/l, regardless of the depth of the aquifer. Depending on the degree of mineralization of the waters, their type varies from hydrocarbon to chlorine with a mixed cationic composition. Water temperature varies from 20 to 160°C, and generally increases with depth, but water horizons with lower temperatures than those located in the upper horizon are often encountered.

A sharp decrease in the degree of mineralization and temperature is recorded at different stages of the studied hydrosphere of thermal aquifers.

Saatli SG-1, which has a depth of 8263 meters, was drilled in the eastern part of the Middle Kura basin, which is limited by depth cracks, which represents a large piece raised in the Kurdamir-Saatli outcrop [10-12]. Gas composition of thermo-mineral waters of the Republic. The natural sources of the mountain layers are clearly divided into two parts: The Greater Caucasus and the Lesser Caucasus, where most of the Talish sources are nitrogen-methane-hydrogen sulfide gas mixture and carbon sources.

The purpose of the work is to determine the quantitative, qualitative and thermodynamic parameters of thermal waters, as well as the spatial structure of the formation centers of their migration paths.

2 The potential of geothermal energy sources in mountainous regions of Azerbaijan

The Republic of Azerbaijan is rich in thermal waters located in a number of areas of the Greater and Lesser Caucasus, the Absheron Peninsula, Talysh, with famous water resources. Underground sources were discovered by numerous wells dug especially for thermal waters in the wide area of Kura depression and Kalbajar-Lachin region.
In the Lesser Caucasus, thermal springs are mainly grouped in the territories of Tartar and Arpachay rivers [13, 14]. The geothermal stage for the springs is 2-3 m/°C. The measurements of the Kalbajar-Lachin region show that the water temperature at a depth of 100 m is 80°C, in the Istisu region at a depth of 60-70 m - 62°C, at a depth of 300-350 m - 75°C. The total flow rate of water in the Upper Istisu region is 800-900 m^3/day, and in the Lower Istisu it is 25 m^3/day. The chemical composition of water is carbon, chloride-sulphite-bicarbonate-sodium. Thermal waters are widely used for balneological purposes [16-18].

3 Complex use of geothermal sources in mountainous regions

Geothermal energy is the heat in the earth that creates geological phenomena on a planetary scale. The main sources of this energy are due to the radioactive transformation of potassium, thorium, and uranium in the earth's crust, or heat flow from the earth's core and mantle, caused by frictional heat in subduction zones along continental plate margins [19]. Fumaroles can be identified by the surface expression of hot springs, geysers, volcanic eruptions, and lava flows. Geothermal energy is generally used to refer to the portion of the Earth's heat that can be recovered and exploited by mankind. Reserves are large, widely renewable, and available almost anywhere in the world, depending on the depth of the source and the economics of producing it.

Thermal waters are used for many purposes - electricity generation, central heating and cooling, hot water supply, agriculture, animal husbandry, fish production, food, oil production industry, balneology and spas, and recreation. The use of geothermal energy is a promising way to achieve clean sustainable development of the world. Many countries have abundant high- and low-temperature geothermal resources, and good progress is being made in exploiting them [20]. For example, in Russia, geothermal resources are mainly used for heat supply and heating of several cities and settlements in the North Caucasus and Kamchatka. In addition, deep heating is used for greenhouses in some regions of the country. The most active hydrothermal resources are used in the Krasnodar Territory, Dagestan and Kamchatka. At the same time, the problem of the most efficient use of natural raw materials is included in the category of urgent tasks, including thermomineral waters and brines. Involvement of these waters in economic activities can help to solve some social-economic and environmental problems [15].

4 Modern control systems of geothermal resources in mountainous regions

Thermal waters are used for many purposes - power generation, central heating and cooling, hot water supply, agriculture, livestock farming, fish farming, food, chemical and oil industries, balneology and resorts, as well as for recreational purposes. Thermal waters, especially chloride brines, contain a large complex of metallic and non-metallic micro components [21, 22]. The saturation of brines with micro components largely depends on both the genetic nature of the brines and the lithological-structural and geothermal characteristics of the rocks that compose them. The interest in geothermal waters and brines as mineral raw materials is associated with several advantages of these types of raw materials compared to solid sources of rare elements, metals and mineral salts.

Industrial groundwater is characterized by a wide regional distribution. They are multi-component raw materials and can be used in balneology and power system at the same time. The extraction of these raw materials requires small capital works and is carried out by drilling, which allows obtaining hydromineral raw materials from great depths.

Geothermal waters and salts are characterized by the variety of mineralization, composition and quantitative ratio of useful components, as well as gas structure and temperature. The most widespread types of hydromineral raw materials are: thermal brines of intercontinental rift zones; thermal waters, salts of the island arcs and areas of the Alps; water and salt water of artesian pools; brines of modern marine or oceanic evaporite pools and continental lakes; sea waters.

The profitability of industrial use of certain components from hydromineral raw materials depends not only on their concentration, but also on the depth and permeability of groundwater, filtration properties of rocks, consumption of labor resources, etc. Economic indicators are affected by the disposal of wastewater for environmental protection.

Based on the general conditions and patterns of distribution of underground geothermal waters and salts with rare elements, as well as taking into account the experience of using water as a hydromineral raw material in Russia and abroad, the following limits of element concentrations in waters (mg/l) are of industrial interest: iodine - 10, lithium - 10, cesium - 0.5, germanium - 0.5, bromine - 200, rubidium - 3, strontium - 300 [12].

Before the Second World War, the technology for extracting lithium, one of its components, from hydro-mineral raw materials was developed abroad, particularly in the United States. By the 1970s, this method accounted for 85% of global lithium production [20].

I, Br, B, Li, As, Ge, W and a number of mineral salts are industrially extracted from geothermal underground brines in Japan. In Israel, carnallite, bromine, magnesium and calcium chlorides, as well as raw materials for the production of medicines and perfumes, are extracted from the brines of the Dead Sea. In the 1980s, hydromineral raw materials provided 30% of the world's lithium production, 31% of cesium, 8% of boron, 5% of rubidium, as well as significant quantities of Ca, Mg, Na, K, S, Cl, U, Ra, Cu [21].

Large reserves of rare metal raw materials are found in geothermal underground waters and salts in the territories of Russia and the CIS. They contain more than 55% of the total reserves of lithium, 40% of rubidium and 35% of cesium [6].

Thermal waters with high mineralization are found in many regions of Russia and the former USSR, and are known in nearly all major fields. In the Perm and Kuybyshev regions, as well as in Tatarstan, Moscow, Ryazan, and other central areas, brines with a mineralization greater than 200 g/l have been identified [22]. For example, chloride brines with a mineralization of 274 g/l can be found at a depth of 1650 meters in Moscow. Large deposits of high-temperature brines are also present in Western and Eastern Siberia, with mineralization levels ranging from 400 to 600 g/l. Additionally, numerous thermal springs are found in Central Asia, Kazakhstan, Ukraine, Kamchatka, the Kuril Islands, and Sakhalin [3]

There are chemical elements that can only be obtained from groundwater. Since iodine is highly soluble and does not accumulate in rocks, iodine is obtained from salts. Iodine is concentrated in seaweed, but industrial raw materials for the production of this seaweed are effective only with their large blockage. Bromine can be obtained from some salts and seaweed, but traditionally bromine is also obtained from concentrated chloride brines.

Geothermal heat supply scheme using aggressive geothermal waters (figure 1).

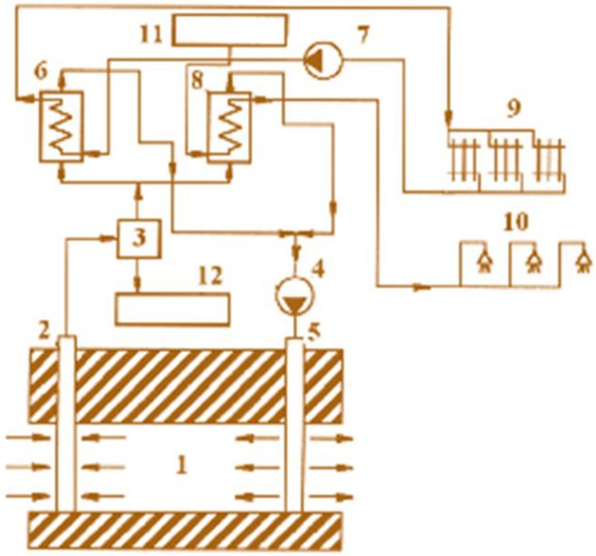


Fig. 1. Geothermal heat supply scheme using aggressive geothermal waters: 1 - underground collector; 2 - reception well; 3 - gas sediment separator; 4 - discharge pump; 5 - injector well; 6 - heat exchanger of the heating system; 7 - heating system pump; 8 - heat exchanger of the hot water supply system; 9 - heating system; 10 - hot water supply system; 11 - hot water source; 12 - gas and sediment disposal system

As an example, Figure 2 shows one of the schemes of using geothermal water for heating and hot water supply, taking into account water of special aggressiveness that cannot be used directly.

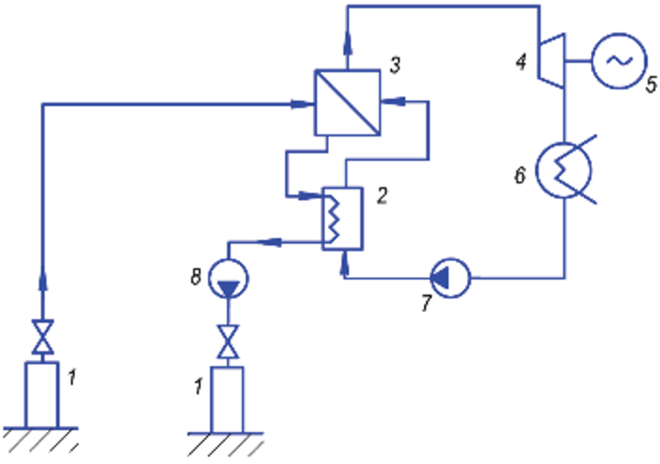


Fig. 2. Schematic diagram of a double-circuit geo-PP: 1 - well; 2 - heat exchanger; 3 - steam generator; 4 - turbine; 5 - electric generator; 6 - air-cooled condenser; 7 - condensate pump; 8 - discharge pump.

Geothermal power plants (geo-PPS) have a number of features:

• constant increase of energy reserves, which ensures the use of the fully installed capacity of the equipment of geo-thermal power plants;

• a fairly simple level of automation;

• consequences of possible accidents are limited to the territory of the station;

• specific capital investments and the cost of electricity can generally be lower than for power plants using other renewable energy sources.

An effective way to combat corrosion from dissolved gases is water disinfection with special devices that remove aggressive components - hydrogen sulfide and carbon dioxide (Figure 3).

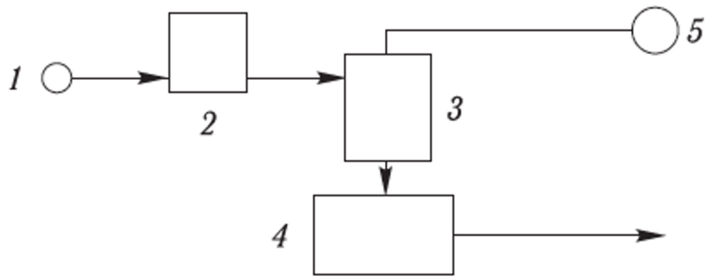
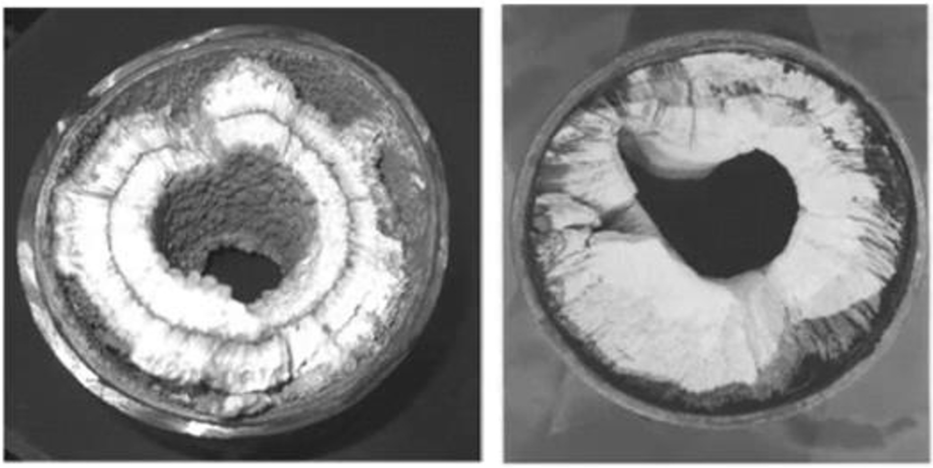


Fig. 3. Scheme of vacuum degassing of thermal waters: 1 geothermal well; 2 - degasser of the first stage; 3 - degassing column; 4- Carbonated water tank battery; 5 vacuum pumps.

To prevent corrosion of equipment and infrastructure, double-circuit geothermal heating systems with intermediate heat exchangers are used. In these systems, freshly softened water is heated by geothermal energy, which is then supplied for subsequent consumption. However, the primary circuit connections, which are in contact with the heat exchanger and geothermal coolant, are prone to corrosion (see Figures 4 and 5).



a) *b)*

Fig. 4. Salt deposit. a - at the bend of a pipe with a diameter of 250 mm (Ternair geothermal field); b - in the discharge line in a pipe with a diameter of 100 mm

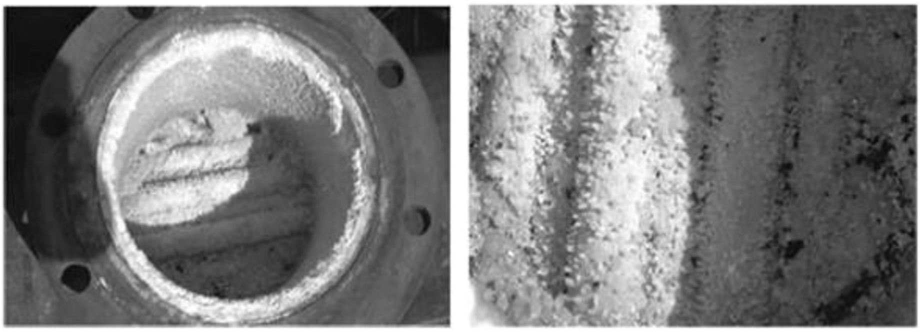


Fig. 5. Salt deposition in a shell and tube heat exchanger.

Salt deposits in pipes of geothermal systems have a clear crystalline nature. The degree of adhesion and the size of the crystals depend on the temperature and pressure at which the scale is formed.

Observations of the precipitation of calcium carbonate in water bodies of different chemical composition, mineralization, temperature and pressure, temperature and pressure at the wellhead, presence of suspended particles, etc., showed that calcium carbonate precipitation occurs at a strictly defined place along the route for the water of various wells.

Most often, calcium carbonate deposits occur behind the valves, where the pressure drops sharply. At the beginning, the deposits in the pipe have the character of an island, then a ring of continuous layers is formed, on top of which new layers are formed.

To prevent calcium carbonate deposits, polyphosphate water treatment is used, or the pH value is maintained at 6.5-7.5, which ensures water stability by adding sulfuric acid to the water content.

Deep degassing of thermal waters allows solving scaling and corrosion problems (Fig. 6).

Water from the well enters a vacuum degasser and then a storage tank. A storage tank is also a tent for the mineral sediment that falls under the water after it has fallen from the gas to the water. A circuit has two parallel lines. While one line is working, the second is cleaned of accumulated sediment.

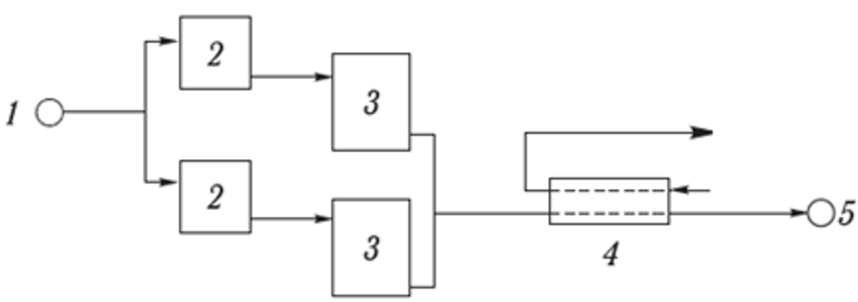


Fig. 6. The scheme for the preparation of thermal waters with a tendency to expansion: 1-warehouse; 2-vacuum degasser; 3-heat exchanger; 4-production well; 5-injector well.

Water from the storage tank is sent to the heat exchanger, where the heat is transferred to the freshly softened water, which is then sent to the heat supply system. Waste thermal water is sent to the surface discharge, and if there are components that prevent such discharge, it is injected back into the reservoir.

5 Conclusions

The issue of assessment and management of the possibilities of integrated use of geothermal waters has been studied and satisfactory results have been obtained: depending on the composition and characteristics of thermal waters, two main areas of use of geothermal resources have been identified: thermal energy and mineral raw materials; To ensure the integrated use of thermal waters, the corrosion process in pipelines through which these waters are discharged has been studied; To ensure the integrated use of thermal waters, a chemical treatment unit has been proposed in the proposed system. To further expand the integrated use of thermal waters, it has been proposed to use the water obtained at the outlet for irrigation.

References

1. Butuzov, V. A., Amerkhanov, R. A., & Grigorash, O. V. Geothermal power supply systems around the world and in Russia: State of the art and future prospects. Thermal Engineering, 65, 282-286. (2018).
2. Mavritsky, B. F., Lokshin, B. A., & Wolfenfeld, A. V. Forecast reserves of thermal waters of the USSR and possible volumes of implementation of geothermal heat supply. Moscow: Nauka 1973. Pp. 87, 97. (1973).
3. Butuzov, V. A., & Tomarov, G. V. Geothermal energy of Kamchatka. Thermal Engineering, 67, 820-832. (2020).
4. Korytny, L. M., Gagarinova, O. V., Ilyicheva, E. A., & Kichigina, N. V. A geographical approach to water resource mapping for atlases. Geography, Environment, Sustainability, 13(2), 96-103. (2020).
5. Dyadkin, Yu.D. Development of geothermal deposits. Moscow, Nedra, (1989).
6. Kremnev, O. A., Zhuravlenko, V. Ya., & Shurchkov, A. V. Technical and economic assessment of geothermal heat supply systems. Study and use of the deep heat of the Earth: Collection of articles, 60. (1973).
7. Morozov, Yu. P. Extraction of geothermal resources and heat accumulation in underground horizons. Naukova dumka. (2017).
8. Lokshin B.A. The use of geothermal water for heat supply. Moscow, Stroyizdat, (1974).
9. Soltani, M., Kashkooli, F. M., Dehghani-Sanij, A. R., Kazemi, A. R., Bordbar, N., Farshchi, M. J., Dusseault, M. B. A comprehensive study of geothermal heating and cooling systems. Sustainable Cities and Society, 44, 793-818. (2019).
10. Tomarov, G.V., Nikolsky, A.I., Semenov, V.N., Shchipkov, A.A. Geothermal energy. Moscow, Teploenergetik, (2015).
11. Dzhamalov, S. A. (1973). Economic efficiency of using thermal waters for heating cities (using Makhachkala as an example).
12. Bundschuh, J., & Tomaszewska, B. (Eds.). Geothermal water management. CRC Press. (2018).
13. Alkhasov, A.B., Alkhasova, D.A., Ramazanov, A.M., Kasparova, M.A. Prospects for the development of high-temperature, high-mineralized resources of the Tarumovo geothermal field. Teploenergetika, (2016).
14. White, D. E. Geothermal energy. Bulletin Volcanologique, 29, 481-483. (1966).
15. Sanner, B., Karytsas, C., Mendrinos, D., & Rybach, L. Current status of ground source heat pumps and underground thermal energy storage in Europe. *Geothermics*, *32*(4-6),

579-588. (2003).

16. Butuzov, V. A., Tomarov, G. B. Geothermal energy saving of the southern region of Russia. Resources, usage, prospects. Lambart Academy Publishing. Saar-Brucken, Germany. (2012).
17. Butuzov, V.A., Tomarov, G.V., Bryantseva, E.V., Butuzov, V.V. Research and design of the geothermal heat supply system. Explanatory note to the map «Distribution of gases in thermal waters of the USSR. Moscow, (2002).
18. Islamzade, A. V., & Mukhtarov, A. S. Geological conditions for the development of geothermal energy in Azerbaijan. Geofizicheskiy Zhurnal, 46(3). (2024).
19. Garibov, A. A., Mikayilova, A. C., Humbatov, F. Y., Ghahramani, M. R., Nagiyev, J.A. Radioecological research of some water resources in central region of Azerbaijan. *International Journal of Radiation Research*, *18*(2). (2020).
20. Agayev, F., Karimov, J., Mehdiyeva, A., & Guliyeva, S. Design principles of digital-to-analog conversion in information transformation. *Technology audit and production reserves*, *5*(1/67), 18-21. (2022).
21. Mehdiyeva, A.M., Quliyeva S.V. Control mechanism to manage quality of energy conversions. Science. Engineering. Technology. (Polytechnical bulletin). № 1, (2022).
22. Zeynal, Z. K. Physical-chemical and treatment peculiarities of Azerbaijan mineral waters and their use in health tourism. Journal of Geology, Geography and Geoecology, 31(3), 566-574. (2022).