Baku State University Journal of Earth Sciences & Environment **2024**, v 2 (2), p.51-56

journal homepage: http://bsuj.bsu.edu.az/en

ON THE HYDROGEOLOGICAL CONDITIONS OF THE LIBERATED AGHDAM DISTRICT

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Abstract

Before the occupation, Aghdam district, with an area of 1250 km², was one of the most developed regions of the republic. Although the district's terrain is predominantly flat, part of it is mountainous. Approximately 77.4% of its area, that is 846.7 km², was occupied by Armenia. After the liberation of the area, it became necessary to clarify the freshwater potential of the region and to take measures for its efficient utilization, particularly in the context of restoring agricultural and livestock activities, as well as ongoing global climate changes.

This article utilizes data from exploration drillings conducted over the past two years. Based on a comprehensive study of this data, along with the summarization of archival and technical literary materials, the hydrogeological conditions of groundwater and confined waters have been clarified, and the hydrological conditions of the studied area have been analyzed.

Keywords: groundwater, confined waters, aquifers, chemical composition, degree of mineralization

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1. Introductıon

Agdam district, covering an area of 1094 km², is located in the contact zone between the Lesser Caucasus Mountains and the Kura-Araz Lowland, in the foothill part of the Karabakh Plain. Its geographical location is very favourable for habitation and agriculture, with a mild warm and dry subtropical climate. As elevation increases in the foothill areas, the climate becomes milder, and the annual precipitation ranges from 300 to 550 mm, with most of it falling in the foothill regions. The average temperature varies from -0.2°C to 1.8°C in January and from 23°C to 26°C in July [1, 4].

2. Research Method. The research method includes the processing and analysis of geological and geophysical data from exploration drilling conducted in recent years, the use of chemical analysis data of water samples, and the study of the current hydrological conditions of the investigated area. The article analyzes and utilizes materials from the hydrogeological study history of the Agdam district.

3. Objective. The objective of this work is to determine the sufficiency of potential freshwater reserves for supplying urban and rural areas, including the irrigation of agricultural lands, and to develop efficient utilization methods for these resources.

4. Discussion of Results. With the ongoing global climate changes and the liberation of approximately 80% of the Agdam district from Armenian occupation, there has arisen a need to restore agricultural and livestock activities, as well as to ensure the provision of quality drinking water to the city and newly resettled areas. To this end, we have conducted investigations into the current hydrogeological conditions of the area.

The Upper Mil canal, constructed for irrigation purposes, passes through the research area. However, due to recent global climate changes, there has been a decrease in water levels in both the Kura River, which feeds the canal, and the canal itself, necessitating the use of groundwater.

The unique natural characteristics of the region, the lithological diversity of Quaternary deposits, and irrigation and reclamation activities have created a complex hydrogeological environment in the studied area. The region is rich in groundwater, which is found in Upper Pliocene alluvial-delluvial and proluvial layers.

In 2021-2022, three exploration wells, each 170-174 meters deep, were drilled to clarify the groundwater reserves of the liberated areas of Agdam district and to use them for public and economic needs. The locations of these wells are illustrated as follows.

Fig. 1. *Location of the Three Exploration Wells Drilled in 2021-2022*

To determine the quality of the water, samples were taken from the exploration wells. Some of the chemical analysis data are provided in the table below. This table shows the quality indicators for water from the three wells, ensuring that the collected data can be used to assess the suitability of the groundwater for drinking and agricultural purposes.

The unique natural features, the diversity of the lithological structure of the Quaternary deposits, and irrigation and reclamation activities have created a complex hydrogeological condition in the studied area, which is rich in groundwater located in the alluvial-delluvial and proluvial layers of the Upper Pliocene period. Groundwater is widespread in the massif and is fed by irrigation water from rivers, canals, precipitation, and vertically seeping confined waters [2, 3].

In areas dominated by irrigation and atmospheric precipitation, groundwater levels rise from March to April and continue until August. From mid-September to the end of October-November, levels decrease due to evaporation. The absolute value of groundwater levels in the vicinity of Agdam ranges from 200 meters to -3 meters towards the Kura River. The thickness of groundwater decreases from 50-60 meters in the foothill areas to 4-5 meters near the Kura River.

Table 1. Chemical analysis of water samples was taken from wells

Parameter	Unit	Standard	W.1	W.2	W.3
Odor at 20°C	score	≤2	0	0	0
Color	degree	≤20	1	17	1
pH	pH units	6-9	7.11	7.55	7.57
Total hardness	mmol/l	≤7	7.60	6.90	6.80
Mineralization	mg/l	≤1000	615.8	884.7	759.3
Dry residue	mg/l	≤1000	448	747	613
Calcium (Ca^{2+})	mg/l	≤100	98.2	152.3	98.2
Magnesium (Mg^{2+})	mg/l	≤50	32.8	29.2	23.1
Sodium (Na^{+})	mg/l	≤200	17.2	53.4	180.2
Potassium (K^{+})	mg/l	≤12	0.5	1.6	4.3
Bicarbonate (HCO_3^{-})	mg/l	-----	335.5	274.5	292.8
Sulfates (SO_4^{2-})	mg/l	≤500	104.4	345.0	124.0
Chlorides (Cl^{-})	mg/l	≤350	23.0	21.6	18.1
Nitrates (NO_3^{-})	mg/l	≤45	3.2	5.6	8.2
Nitrites (NO_2^{-})	mg/l	≤3	0.018	0.017	0.056
Fluorides (F^{-})	mg/l	≤0.7	0.38	0.33	0.38
Iron (Fe)	mg/l	≤0.3	0.26	0.23	-
Boron (B)	mg/l	≤0.5	-	-	0.1
Manganese (Mn)	mg/l	≤0.1	0.087	0.064	0.052
Copper (Cu)	mg/l	≤0.1	0.03	0.35	0.02
Chromium (Cr, VI)	mg/l	≤0.5	0.017	0.013	0
Phosphates (PO_4^{3-})	mg/l	≤3.5	0.20	0.60	0.09
Aluminum (Al^{3+})	mg/l	≤0.5	0.053	0.008	0.014
Nickel (Ni)	mg/l	≤0.1	0.054	0.050	0.048
Cobalt (Co)	mg/l	≤0.1	0.034	0.013	0.027
Barium (Ba^{2+})	mg/l	≤0.1	0.02	0.02	0.05

The total mineralization of groundwater in over 90% of the area is 0.3-0.9 g/l, but it reaches 2-5 g/l at the boundary with the Kura River's deposition cones. The chemical composition of the water changes along the flow direction from bicarbonate to sulfate-bicarbonate and chloride-sodium types. The depth of the water table is influenced by the area's topography, the slope of the flow, the permeability of the rocks, and variations in the recharge regime and discharge, generally decreasing from west to east. The deepest groundwater levels are observed at the apex of river deposition cones, while the shallowest levels occur in interfluve depressions. Groundwater surfaces in the peripheries of the river deposition cones, forming marsh systems. Due to slight gradients in groundwater flow, accumulation in heavy soils, shallow depths, and evaporation, the chemical composition of the aquifers can vary from 1 to 35 g/l in mineralization. In the southeast region, groundwater is recharged by confined waters with a pH of 6.5-7.

As part of the Karabakh Plain, the hydrogeological conditions of Agdam district are similar to neighboring areas, warranting joint study. Five confined aquifers are identified in the area, represented lithologically by sands, sandstones, and large pebbles with sand and sandstone fillers. These aquifers are separated by impermeable clays ranging from 17-20 meters to 100-130 meters in thickness.

The most impactful to the reclamation situation is the first confined aquifer complex, with a roof depth of 20-60 meters to 100-120 meters. The mineralization of this layer varies from 0.5 g/l to 3.0 g/l, with chemical composition ranging from bicarbonate to bicarbonate-sulfate and sulfate types. This aquifer is exposed at depths of 20-100 meters in the east and central parts of the area, with the aquifer thickness ranging from 5-110 meters. While this aquifer is generally fresh, it is saline between Khachinchay and Tartarchay rivers and on the left bank of the Kura River (figş2).

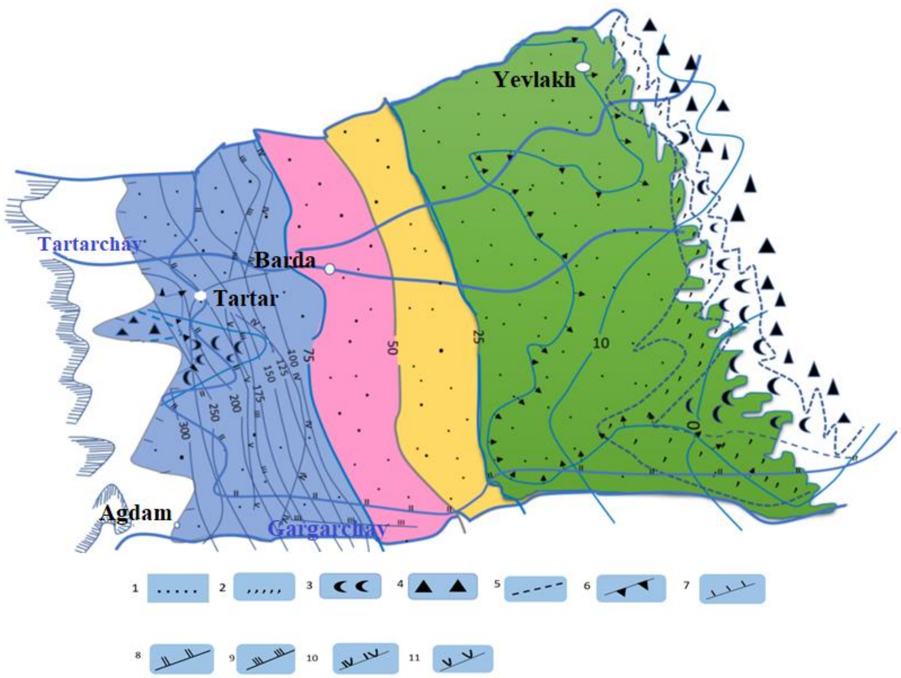

Figure 2. General mineralization map of pressurized waters of the Karabakh Plain
Dry residue in the waters of continental sediments: 1-1g/l, 2-1-1.5g/l, 3-1.5-3g/l, 4-3-10g/l. Boundaries: 5- pressure water of different quality, 6- distribution of pressure water: 7- first, 8- second, 9- third, 10- fourth, 11- fifth.

The second confined aquifer is less widespread, with depths ranging from 40-100 meters to 180-220 meters. The thickness of impermeable clays varies from 10-45 meters. The lithological composition includes gravel-pebbles, sands, and sandstones. Pressure from the roof ranges from 60-65 meters to 230-240 meters. This aquifer is predominantly fresh, though occasionally mineralized up to 1.8 g/l, with mineralization levels between 1.0-1.5 g/l and chemical compositions of bicarbonate, bicarbonate-sulfate, and sulfate-bicarbonate types.

The third confined aquifer complex is even less extensive, with a roof depth of 150-300 meters and lithological composition of gravel and sand underlain by impermeable clays 20-60 meters thick. Chemical composition varies from bicarbonate-sodium to bicarbonate-sulfate-sodium and sulfate-bicarbonate-sodium, with overall mineralization not exceeding 0.5 g/l.

The fourth confined (Absheron) aquifer is similarly distributed, with depths of 135-400 meters and more. It is not found on the left bank of the Kura River. Permeability coefficients range from 0.9-18.7 m/day, aquifer thickness from 20-40 meters, discharge from 0.6-23.20 l/s, and specific discharge from 0.1-0.8 l/s/m.

The fifth confined aquifer is exposed at depths of 200-280 meters in the central part of the plain. Permeability coefficients are 4.5-5.0 m/day. While the groundwater and the first four confined aquifers have fresh water, this fifth aquifer is saline [2-5].

Khachinchay, a left tributary of the Kura River, flows through the districts of Agdam, Agdere, and Barda, with a length of 119 km and a basin area of 657 km². It originates from springs on the Hacigurd (2397 m), Uyukhlu (2316 m), Chichekli (2343 m), and Alagaya (2583 m) mountains of the Karabakh range, and a reservoir with a capacity of 23 million m³ has been constructed on the river.

Until 1990, about 800 water wells were drilled mainly in the eastern part of the district. Currently, the condition of these wells is being clarified, and a comprehensive monitoring of water sources has begun. During the occupation, Agdam's forest areas were also destroyed, with 25,000 hectares of forest cleared and converted to agricultural land. Valuable reservoirs were demolished. Before the occupation, there were three reservoirs on the Kondelenchay River with a total capacity of 14,000 m³. After the liberation of the Karabakh region, these reservoirs were quickly restored and will soon play a major role in irrigating the lands of Agdam and Fuzuli districts. The reservoir on the Gargarchay River has also been restored, and plans to expand it are currently underway.

The hydrogeological and hydrological analysis of the Agdam district and the entire Karabakh region indicates that the district has sufficient water resources for both irrigation and drinking water supply. Concurrently, the efficient use and management of surface and groundwater resources require monitoring. Measures should be implemented in accordance with the requirements of the "smart village and smart city" projects [1, 3].

Previously, two canals were constructed from the Tartar River, supplying water from Agdere to Agdam. Soon, water from the Upper Karabakh canal will also be directed to Agdam, and many artesian wells will be restored or re-drilled to join the water supply system.

In conclusion, efforts are underway to restore water resources for drinking and irrigation and to manage them in line with "smart village and smart city" project standards.

The saturated complexes of Khachinchay's deposition cones have a thickness of 35-96 meters, a permeability coefficient of 8.1-50.6 m/day, a width of 1.5 km for underground flow, and a discharge of 140.7 l/s. The aquifers of the Gargarchay river's deposition cones have a thickness of 37-95 meters, a permeability coefficient of 17.6-41.9 m/day, a width of 1.5 km for underground flow, and a discharge of 323 l/s.

5. Conclusıon

1. In the area, five artesian aquifers and one shallow groundwater horizon are distributed. The first three artesian aquifers are separated within the IV epochal formations. The fourth and fifth aquifers are situated within the Aghjagil and Absheron tiers of the formations. Their chemical composition consists of calcium-magnesium, hydrocarbonate, hydrocarbonate-sulfate saline waters. The pH indicator increases from 6.9 to 8.6 in the direction of the Kura River.

2. In the formation of groundwater regime characteristics, infiltration and percolation waters play a crucial role. To enhance the productivity of irrigated soils and protect them from salinization, salt accumulation within the active soil layer must be prevented. Maintaining the desired moisture concentration for plants requires adhering to a specific water regime. Monitoring the distribution of groundwater for

irrigation according to predefined and calculated norms is essential to prevent waterlogging.

3. To significantly improve irrigated soils, agro-technical, comprehensive utilization, organizational, and hydro-meliorative measures must be implemented. Enhancing meliorative conditions can be achieved through the regulation and improvement of irrigation methods and by enhancing the effectiveness of drainage systems to prevent waterlogging.

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К оценке гидрогеологической обстановки деокупированного Агдамского района

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Резюме. Агдамский район площадью 1250 км^2 до оккупации являлся одим из самых развитых регионов республики. 77,4% его территории, то есть 846,7 км^2, было оккупировано Арменией. Рельеф Агдамского района в основном равнинный, но некоторая часть его гористая. После освобождения территории для восстановления сельскохозяйственной и животноводческой деятельности, а также в связи с происходящими глобальными изменениями климата возникла необходимость уточнить потенциал пресной воды исследуемого региона и принять меры для его последующей эффективной эксплуатации.

В статье использованы данные разведочного бурения, проведенного за последние два года. На основе всестороннего изучения этих данных, а также обобщения фондовых и технических литературных материалов уточнены гидрогеологические условия залегания подземных и напорных вод, проанализированы гидрологические условия исследуемой территории.

Ключевые слова: подземные воды, вода под давлением, водоносные горизонты, химический состав, степень минерализации.