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MODERN HYDROGEOLOGİCAL CONDİTİONS OF THE ABSHERON PENİNSULA

(Представлено членом редакційної колегії д-ром геол. наук, проф. О.Є. Кошляковим)

Background. ***The Absheron Peninsula is the most densely populated and ecologically polluted area in the Republic of Azerbaijan. The rapid development of the oil industry in this area has had a negative impact on both the sea and a significant part of the peninsula. This article examines the physical and geographical conditions, geological and geomorphological structure, and the physico-mechanical properties of rocks from a hydrogeological perspective. By summarizing data on the depth, flow rate, and chemical composition of groundwater and evaluating factors that play a significant role in the formation of the area's hydrogeological conditions, reasons for the rise in groundwater levels have been established, and solutions for their elimination proposed. The aim of the study is to investigate the causes of ecological imbalance, identify factors affecting the modern hydrogeological conditions of the Absheron Peninsula, and suggest preventive measures against potential geological events. The peninsula's hydrographic network consists of the Caspian Sea, streams, numerous saline lakes fed by atmospheric precipitation and oil-containing waters, with lakes having a significant impact on the climate and ecological situation in this densely populated area.***

Methods. ***Research methods involve studying the physico-mechanical properties of soil and rock samples collected from hand-dug wells and boreholes in terms of engineering hydrogeology, their lithological composition, and thickness.***

Results. ***The charachteristics of the artificial lakes, reservoirs, villages, and settlements of the Absheron Peninsula, as well as its unconfined and confined aquifers are studied in the article.***

Conclusions. ***The results have revealed the modern hydrogeological conditions across the entire area of the Absheron Peninsula, as well as natural and anthropogenic factors influencing its formation. Based on these factors, it is possible to predict endogenous and exogenous geological events and take appropriate preventive protective measures. Based on the results of preliminary assessment and earlier hydrogeological zoning, 12 promising areas were identified in 3 hydrogeological areas.***

Keywords: ***Absheron Peninsula, hydrogeological conditions, ecologically polluted area, groundwater, artesian aquifers, physico-chemical composition.***

Background

Located on the eastern edge of the Greater Caucasus and on the western coast of the Caspian Sea within the Republic of Azerbaijan, the large Absheron Peninsula borders Gobustan. Its length is about 60 km, with the widest part reaching 30 km. The surface of the Absheron Peninsula comprises broad plains, ridges, and hills, separated by valleys and depressions. The western part of the peninsula is situated at higher elevations, while the coastal area lies 28.0-28.5 m below sea level (Alekseev, 2020; Geology of Azerbaijan, 2008; Imanov, & Alekbarov, 2017; Karimov, Sharifov, & Mammadli, 2021).

Research on the hydrogeological conditions of the Absheron Peninsula and the factors affecting its formation is of current importance and represents scientific and practical interest. Such studies are crucial for urban planning and construction, selecting territories for water dams, bridges, rail, and roads construction, considering the durability of engineering structures, normal economic activities, predicting endogenous and exogenous geological events (swamps, salinization, landslides, etc.), and developing protective measures against them.

The study also examines temperature indicators, annual precipitation norms, seasonal changes in groundwater levels, as well as their physico-chemical composition, conditions of formation, replenishment, and the potential for use in drinking water and for economic needs.

The hydrogeological conditions and influencing factors, physical-geographical conditions, geological and geomorphological structures, and physico-mechanical properties of rocks, along with endogenous and exogenous phenomena, must be evaluated from a hydrogeological perspective. The Absheron Peninsula mainly hosts the cities of Baku, Sumgayit, Khirdalan, and 32 other settlements, with its orography represented by low mountains in the northwest and southwest, and plains in the central and eastern parts.

The geological structure includes several tectonic structures. The West-Absheron anticlinorium, the Absheron-Jeyrankechmez tectonic zone, the East-Absheron synclinorium, and the Absheron Archipelago anticlinorium, each characterized by its unique geological and geomorphological features. From a geomorphological viewpoint, the peninsula's relief was mainly formed under the influence of dynamic young tectonic movements and abrasion, including exogenous geological factors.

The peninsula's hydrographic network consists of the Caspian Sea, streams, numerous saline lakes fed by atmospheric precipitation and oil-containing waters, with lakes having a significant impact on the climate and ecological situation in this densely populated area. Due to evaporation exceeding annual precipitation three to four times, these lakes tend to dry up and accumulate salt deposits during summer (Amalfitano et al., 2014; Barthel, 2014; Bondarenko et al., 2018; Bravo, 2019; Gadzhiev, & Namazov, 2014).

The rapid industrial development in Absheron has led to population growth and construction of many residential areas without a unified sewage system, worsening the ecological condition of nearby lakes and territories, with lakes such as Boyukshor, Bulbula, Kirmizygol, Khodjasan, and Chukhurdara being the most polluted ones, hindering the expansion of Baku city.

The East-Absheron synclinorium is characterized by deposits from the Quaternary and Agchagyl ages and a productive layer, marked by complex geological structures and consists of various anticlinal uplifts like Sumgayit, Jorat, Novkhani, Fatmai, Garachukhur, Zigh, and the Sandy Island in the Caspian Sea, uniquely stretching in the northeast and southeast directions. The Absheron Archipelago anticlinorium, following a general Caucasian direction, features a series of anticlinal uplifts: Oil Rocks, Yylag, Pirallahi, and the Absheron Bank, extending along the northeastern coast of the peninsula and separated by synclinal depressions. Geomorphologically, the peninsula's relief was primarily shaped by dynamic young tectonic movements and abrasion, including exogenous geological factors. Western Absheron is known for its fragmented relief, predominantly consisting of mountainous areas reaching 370 m in height, connecting with exposures of the Greater Caucasus. Eastern Absheron, east of the Mastaga-Surakhani meridian, presents as a rounded hilly plain. The southwestern part of the peninsula features elevations of 120–130 m. The northwest consists of plains facing the Caspian Sea, represented by coastal terraces, while the area east of the Sumgayit River is a saline depression. The southwest is characterized by saline, dune, and barchan plains of Turkhan and Zira. Hills along the Caspian Sea are shaped by temporary watercourses due to rain and snowmelt. The hydrographic network includes the Caspian Sea, streams like Jeyranchel and Sumgayit, and numerous saline lakes fed by atmospheric precipitation and oil-containing waters, with mineralization levels of 10–100 g/l and a chlorinated, chloro-sulfate-sodium-magnesium chemical composition. Out of the 222,000 hectares of the peninsula's total area, 30,000 hectares have lost their natural potential due to topsoil erosion and are unsuitable for use, though not all are polluted. The oil-polluted part accounts for about 10,600 hectares, with the most polluted areas being in the Garadagh, Binagadi, Sabunchi, Surakhani, Khazar, and Sabail districts (Gadzhiev et al., 2011; Selvaggi et al., 2020; Gruza, & Rankova, 2004; Gyulmamedov, 2021) (Fig. 1).

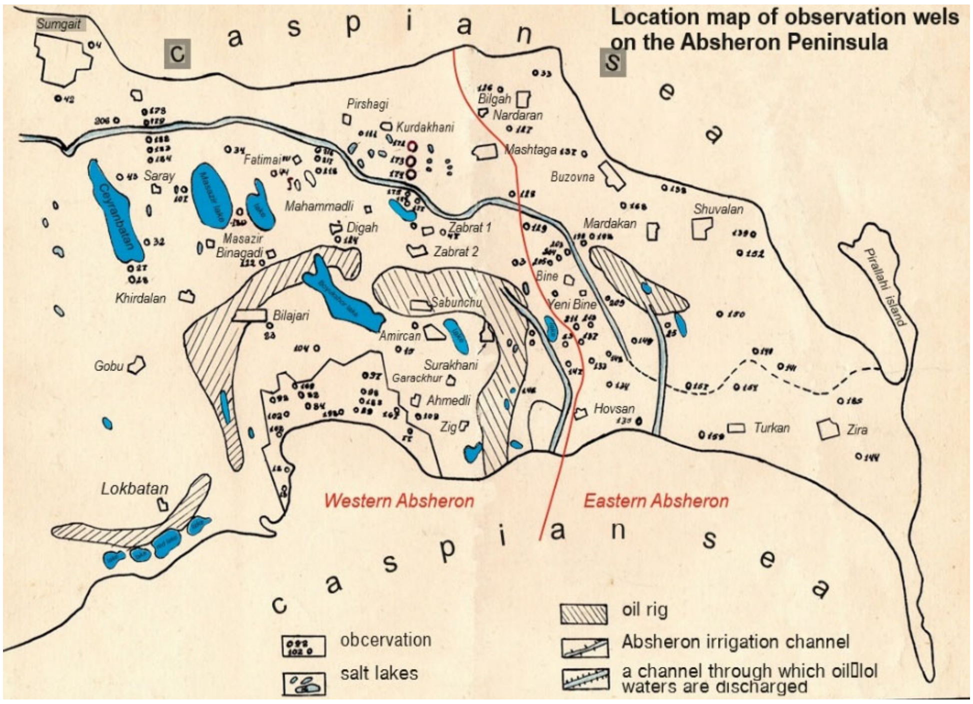


Fig. 1. Lakes of the Absheron Peninsula

Lakes, formed and polluted by industrial and domestic waters, pose significant ecological problems, influencing the climate and environmental situation in this densely populated area (Klige, & Khlystova, 2012; Lee, & Son, 2017; Maksarov, 2023; Montcoudiol, Molson, & Lemieux, 2014; Panteleenko et al., 2023, Smith, & Reynolds, 2003). About 800 lakes cover 3,325 hectares, with 200 being relatively large. Annually, over 40 million cubic meters of wastewater and formation water are discharged into them, exacerbating the lakes' ecological situation due to pollution from oil, industrial and domestic wastewater, and water from many newly built residential and public buildings without proper sewage systems (Wang, Zuo, & Caers, 2017; Wang, Lee, & Son, 2017). With evaporation exceeding annual precipitation by three to four times, these lakes tend to dry up and accumulate salt deposits during summer. Most artificial lakes and ponds were created by long-term discharge of untreated formation water during oil and gas exploration and production. Rapid industrial development led to population growth and the construction of many residential areas. Due to the lack of a unified sewage system, domestic wastewater in residential areas is dumped into nearby lakes and adjacent territories, turning these bodies of water into stressed ecological zones. Lakes like Boyukshor, Bulbula, Kirmizygol, Khodjasan, and Chukhurdara are among the most polluted, limiting the expansion of Baku. Boyukshor Lake, located in the center of the Absheron Peninsula within the Binagadi, Sabunchi, and Narimanov districts, has observed depths of 3.40-3.95 m in open areas, with a maximum depth of 4.20 m. Near the shores, depths vary from 0.50 to 1.70 m. The lake has an oval shape, extending from northwest to southeast, with a length of 10 km and a maximum width of 1.5–2.0 km, surrounded by an ancient Caspian terrace to the north and a rectangular slope to the south. Currently, Boyukshor Lake is a closed basin, receiving groundwater flows from all surrounding territories.

Methods

During the research period, the authors sampled and determined the degree of mineralisation and chemical composition of the waters of some lakes of the Absheron peninsula (Tab. 1).

The Absheron Peninsula features the artificial Jeyranbatan Reservoir and the Absheron Canal. Settlements and industrial areas on the peninsula are supplied with water from the first and second Shollar aqueducts, the first and second Kura, the Oguz-Gabala-Baku, Jeyranbatan and Takhtakorpu reservoirs, and the waters of the Absheron Canal (Gladilshchikova, & Semenov, 2017; Ismailova et al., 2022; Israfilov et al., 2016; Jungmeister, Gasymov, & Isaev, 2022).

Table 1

Hydrochemical characteristics of the Absheron Peninsula lakes

Name of the lake	Chemical composition of waters according to Kurlov's formula	
	At high water level	At low water level
Haji-Hasan	$M_{2,6}\frac{Cl51,1SO_4 35,8HCO_3 13,1}{(Na+K)78,6Mg12,3Ca9,1}$	$M_{1,9}\frac{Cl44,2SO_4 40,4HCO_3 15,4}{(Na+K)89,7Ca6,9Mg3,4}$
Ganly gol	$M_{1,8}\frac{SO_4 49,5Cl37,3HCO_3 13,2}{(Na+K)74,9Mg18,0Ca7,1}$	$M_{1,3}\frac{SO_4 46,7Cl37,0HCO_3 16,3}{(Na+K)69,9Mg20,8Ca9,3}$
Alatava-I	$M_{2,5}\frac{SO_4 71,5Cl16,5}{(Na+K)72,6Ca17,1Mg10,3}$	$M_{2,2}\frac{SO_4 70,1Cl18,1HCO_3 10,6}{(Na+K)71,9Mg16,3Ca11,7}$
Alatava -II	$M_{3,7}\frac{SO_4 71,9Cl16,5}{(Na+K)67,6Mg17,7Ca14,7}$	$M_{3,4}\frac{SO_4 66,7Cl26,4HCO_3 6,9}{Mg58,7Ca24,9(Na+K)6,4}$
Bulbula	$M_{2,0}\frac{Cl42,1SO_4 30,1HCO_3 27,8}{(Na+K)49,3Mg28,8Ca21,9}$	$M_{1,5}\frac{SO_4 49,4HCO_3 28,4Cl22,2}{(Na+K)73,0Mg15,2Ca11,8}$
Beyuk-Shor	$M_{11,0}\frac{Cl76,9SO_4 11,5HCO_3 5,9}{(Na+K)79,1Mg11,8Ca9,1}$	$M_{2,7}\frac{Cl51,8SO_4 33,0HCO_3 11,6}{(Na+K)87,8Mg6,4Ca5,8}$
Mirzaladi	$M_{220}\frac{Cl88,1SO_4 10,6HCO_3 1,3}{(Na+K)92,1Ca1,9Mg6,0}$	$M_{212}\frac{Cl92,2SO_4 6,4}{(Na+K)91,9Mg6,3Ca1,8}$
Gyrmyzy gol	$M_{324}\frac{Cl94,0SO_4 5,0}{(Na+K)92,6Mg7,1Ca0,3}$	$M_{275}\frac{Cl93,6SO_4 5,9HCO_3 0,5}{(Na+K)93,6Mg6,0Ca0,4}$
Masazyr	$M_{435}\frac{Cl97,2SO_4 2,8}{(Na+K)96,4Mg3,2Ca0,4}$	$M_{310}\frac{Cl92,0SO_4 7,2}{(Na+K)93,0Mg4,0Ca2,0}$
Jeiranbatan Reservoir	$M_{0,9}\frac{SO_4 47,9Cl32,8HCO_3 19,3}{Mg47,7(Na+K)39,1Ca13,2}$	$M_{0,2}\frac{Cl45,1SO_4 42,6HCO_3 12,3}{(Na+K)53,9Ca18,7Mg17,4}$

Its geological structure includes Cretaceous, Paleogene, Neogene, and Quaternary deposits. Geomorphologically, the peninsula's relief has primarily formed under the influence of dynamic young tectonic movements, abrasion, including exogenous geological factors. Hydrogeologically, the Absheron Peninsula is divided into Western and Eastern Absheron districts, with groundwater being widespread in the western part, in Baku, and along the northern coast. In the eastern part, groundwaters have formed in various stratigraphic and genetic deposits (Fig. 2).

During 2010–2023, studies, cadastre and report were carried out by Hydrogeological and Amelioration Service and Water Use and Protection Control Department of "Azerbaijan Land Reclamation and Water Management" JSC. The purpose of these researches, which were carried out under the methodological guidance of the authors of the article, is to determine the peculiarities of groundwater formation within the Absheron peninsula, search and assessment of groundwater reserves suitable for drinking and technical purposes, allocation of promising areas for more precise works. In this connection, complex geophysical and hydrogeological studies were carried out in the Absheron territory during the above-mentioned period. The results of previously conducted geological, hydrogeological and geophysical works, as well as data from wells drilled by individuals and legal entities were studied (Fig. 1).

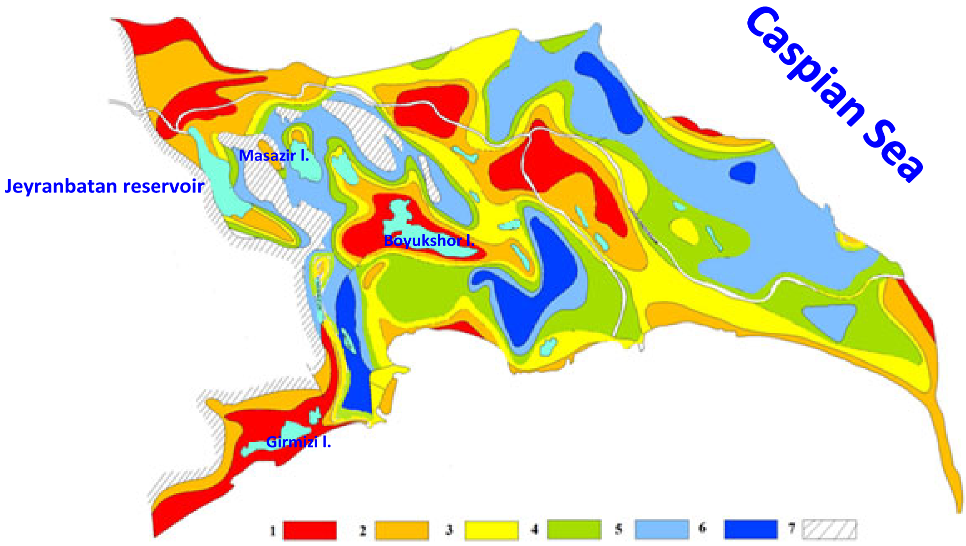
Taking into account these data and preliminary geophysical surveys on the scale of 1:50000, geological and lithological sections of the area, reservoir characteristics of rocks, etc. were identified and promising areas of underground pressure water distribution were identified. By drilling boreholes in promising areas to depths of 10, 50, 100.0 meters, the conditions of water horizons occurrence were studied by area and depth and corresponding maps were drawn up (Fig. 2).

Based on the results of well logging, hydrogeological permeability tests, ground geophysical and laboratory studies, the effective capacity, hydrodynamic and hydrochemical parameters of water horizons were studied. At the same time, by studying the results of previously dug wells, the flow rate and chemical composition of water of the existing water intakes in the territory were studied (Gadzhiev, & Namazov, 2014; Selvaggi et al., 2020; Geology of Azerbaijan, 2008; Gladilshchikova, & Semenov, 2017; Gruza, & Rankova, 2004; Gyulmamedov, 2021; Imanov, & Alekbarov, 2017; Ismailova et al., 2022).

Groundwater is widespread in the Novocaspian deposits of continental origin (alluvial, deluvial, aeolian, etc.), nourished by the waters of the Khvalynsk deposits, mainly flowing horizontally. Wells dug in these deposits yield 0.02–0.2 l/sec, often too saline for water supply use. The Novocaspian aquifer on the Absheron Peninsula appears as a strip along the coast, 60–400 m wide. 70 % of these deposits are sandy shell rocks, 1.0–15.0 m thick, transitioning to clays with depth. Groundwater is uncovered at various depths, sweet to brackish in quality.

The Khvalynsk deposits, mainly found on Western Absheron and water-bearing along the eastern coast, consist of limestones, sands, and gravels in places, with groundwater levels 2.0 to 16–17 m deep, yielding 0.2–0.7 l/sec. In the Baku fold area, groundwater is mostly brackish to saline. Caspian deposits, prevalent in Sumgayit and Baku, vary in depth, often saline, with mineralization levels of 0.9–2.1 g/l, indicating diverse hydrogeological conditions across the peninsula.

During investigations for the construction of a metro line from "Kara Karaev" station towards Bina airport, groundwater was observed at depths of 35.0–65.0 meters. Near the new Baku Oil Refinery, groundwater is found at depths of 12.0–30.0 meters, primarily in Caspian age deposits consisting of sands, limestones, and clays.



Depth of occurrence: 1. 0–1 m; 2. 1–-3 m; 3. 3–5 m; 4. 5–10 m;5. 10–20 m; 6. More than 20 m; 7. Areas of sporadic distribution of groundwater

Fig. 2. Map of the groundwater depth in the Absheron Peninsula

In Bina and the Govsan fold, Caspian deposits' groundwater is accessed by wells at 5.7–23.0 meters, with some yielding 7.01 l/sec. Mineralization increases significantly in the Govsan fold area, mixing with oily waters, reaching up to 100 g/l in outer parts of waste channels. Groundwater associated with the Baku stratum varies in depth around Baku, Sumgayit, Mardakan, and Bina.

Beyond Shuvalan, in an area known as the "Northern TPP" gardens, groundwater is found in sands, limestones, and weakly cemented sandstones at depths mainly between 10.0–18 meters, with a mineralization level of 1.2–2.0 g/l and a sulfate-calcium chemical composition. Groundwater in Baku is found at various depths in sands, limestones, and weakly cemented sandstones, with well yields reaching up to 9.0 l/sec and mineralization levels of 0.7–2.5 g/l, increasing to 67.6 g/l in some areas.

The Upper Absheron water-bearing layer is identified in Bilgah, Gala railway station, Sahil, and Baku fold areas, exhibiting high water yield in some places and serving local sanatoriums. Groundwater in Baku, associated with upper Absheron deposits, is accessed at various depths, generally fresh and low mineralized, with mineralization of fresh spring waters ranging from 0.5–1.2 g/l (Yungmeister et.al., 2022; Tagiev & Karimov, 2021; Tagiev & Babaev, 2016; Tagiev, 2001).

Groundwaters related to the Middle Absheron deposits are identified through wells in various areas, showing different levels of mineralization and water yield. Pressurized freshwater aquifers, widely spread in Eastern Absheron and associated with Quaternary deposits, have been more thoroughly studied in certain areas, with well yields of 0.5–2.0 l/sec and mineralization levels varying. Fresh, slightly mineralised pressure waters are widespread in East Absheron and are confined to Quaternary sediments.

During 2022–2023 years of research the authors sampled and determined the degree of mineralisation and chemical composition of the Absheron Peninsula pressure waters.

Results

The pressure water horizons of Lower Quaternary sediments have been studied in comparatively more detail in the areas of the Baku, Bina-Govsan and Ziryan mulds. The flow rate of wells drilled into these deposits is 0.5–2.0 l/sec, and the degree of mineralisation varies within 12–16 g/l.

In the Bina-Govsan fold, two water-bearing horizons were discovered at depths of 28.5–43.9 m and 47–75 m with yields of 4.0–5.0 l/sec, mostly saline. Due to the pinching out of the Absheron layer deposits, artesian waters emerge as several springs and are accessed by wells with a flow rate of 1.7 l/sec. In the Guzdek fold, artesian waters of the upper Absheron deposits surface through springs and wells, yielding up to 1.7 l/sec (maximum 7.7 l/sec). Artesian waters from the upper and middle Absheron deposits within the Baku fold are accessed at depths of 27–77 m, with mineralization reaching 12–17 g/l. The hydrogeological conditions of the Absheron Peninsula were defined by various factors, including physical-geographic conditions, geological structure, geomorphology, hydrogeological conditions (groundwater depth, flow, composition, mineralization), and the physical and mechanical properties of rocks (Tagiev, 2001; Tagiev et al., 1996; Tagiev, & Babaev, 2017; Tagiev, Kerimov, & Sharifov, 2021; Tagiyev et al., 2022).

These studies identify the modern hydrogeological conditions and both natural and anthropogenic factors influencing the peninsula's formation, aiding in identifying conditions for potential geological events and necessary preventive measures.

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Table 2

Hydrogeological parameters for assessment of drinking groundwater reserves (for 2010–2023)

№	№ well	Absolute mark of the well, m	Well depths	Parameters of water horizons									Filtration factor of rocks, m/day	Water permeability coefficient of rocks, m²/day	Kurlov's formula
				Name and age of rocks	Depth of occurrence, m	Effective thickness, m	Filter interval, m	Static water level, m	Well depth, m	Water level drop, m	Well flow rate, litres/sec	Specific well flow rate, litres/sec m			
1	1^k	18,7	60	$Q_{I}ap$	29–38 46–60	23	28–38 46–56	22,1	35,26	13,16	1,0	0,076	0,55	12,65	$M_{1,1}\frac{SO_4 56xHCO_3 28,4xCl\ 15,5}{(Na+K)53,7xCa27,8xMg18,5}$
2	2^k	22,8	60	$Q_{I}ap$	70–95	17	70–85	12,0	25,0	13,0	0,5	0,077	0,41	6,97	$M_{1,84}\frac{SO_4 47,5xCl37,5HCO_3 15,0}{(Na+K)50,8xMg27,2Ca22}$
3	3^k	7,3	100	$Q_{I}ap$	40–65	25	42–62	4,87	4,46	13,0	1,0	0,77	0,82	20,5	$M_{2,1}\frac{Cl40x3SO_4\ 34,8\ HCO_3 24,9}{(Na+K)60,5xCa19,8xMg19,7}$
4	4^k	-0,3	70	$Q_{I}ap$	4,9–66,0	24	40–65	4,9	9,47	4,57	1,6	0,35	0,51	12,24	$M_{0,74}\frac{SO_4 55,2xHCO_3 40,7xCl4,1}{(Na+K)47,9xCa34,7xMg17,4}$
5	5^k	0,7	70	$Q_{I}ap$	5,7–60	25,0	40–60	5,7	10,3	4,6	1,8	0,39	0,51	12,75	$M_{0,66}\frac{SO_4 43,9xHCO_3 43,1xCl2,2}{(Na+K)\ 45,8xMg33,2xCa221}$
6	6^k	-1,0	70	$Q_{I}ap$	6,28–63	21,0	43–63	6,28	10,02	4,62	1,8	0,37	1,21	25,41	$M_{2,16}\frac{SO_4 44,2xCl37,1xHCO_3 18,7}{(Na+K)62Mg22,2xCa15,8}$
7	7^k	-0,7	70	$Q_{I}ap$	4,1–63,0	22,0	43–63	4,1	13,58	9,48	1,1	0,1	0,39	8,58	$M_{2,18}\frac{SO_4 42,7xCl37,1HCO_3 20,2}{(Na+K)67,6xMg17,5Ca14,9}$
8	8^k	0,8	70	$Q_{I}ap$	4,27–66	20,0	45–65	4,27	13,84	9,57	1,0	0,1	1,43	28,6	$M_{2,34}\frac{SO_4 46xCl33,6xHCO_3 x20,4}{(Na+K)66,2xMg19,3Ca\ 14,5}$
9	9^k	10,7	80	$Q_{I}ap$	2,0–80,0	25,0	53–78	7,9	15,5	7,6	0,6	0,08	0,26	6,5	$M_{2,26}\frac{SO_4 71,7xHCO_3 17,5xCl10,8}{(Na+K)75,6xCa12,8xMg11,6}$
10	11^k	9,2	80	$Q_{I}ap$	2,0–74,0	28,5	35–50 60–64 70–74	12,46	22,38	9,92	0,4	0,05	0,43	12,26	$M_{0,9}\frac{HCO_3 39Cl24SO_4 17,0}{Ca13,1(Na+K)79xMg8,2}$
11	12^k	8,0	80	$Q_{I}ap$	12,46–76,0	40,5	25–55 60–65 70–75	22,46	31,43	8,97	2,24	0,28	1,14	46,17	$M_{0,9}\frac{Cl39,6xHCO_3 34,3xSO_4 28,1}{(Na+K)47Mg29,8Ca28,2}$
12	13^k	11,1	76	$Q_{I}ap$	18,0–30,0 41–50	24,0	41–51	25,46	37,53	12,07	3,01	0,25	0,78	18,72	$M_{1,07}\frac{SO_4 41,1HCO_3 33,1Cl25,8}{(Na+K)63,2Mg23,5xCl13,3}$
13	14^k	20,3	70	$Q_{I}ap$	18–30,0 39–65,0	26,0	40–60	26,7	41,2	14,5	2,8	0,19	0,58	15,08	$M_{3,0}\frac{SO_4 59xCl23xHCO_3 18}{(Na+K)46,7Mg32,9xCa20,4}$
14	15^k	12,5	70	$Q_{I}ap$	19–32,0 41–64	24,0	42–62	17,1	32,9	15,8	2,7	0,59	0,59	14,16	$M_{1,1}\frac{SO_4 46,9xCl27,7xHCO_3 23,4}{Ca38,8xMg38,5x(Na+K)22,7}$
15	16^k	10,8	70	$Q_{I}ap$	40–64,0	31,0	40–60	16,9	32,9	15,3	2,34	0,14	0,21	6,51	$M_{2,07}\frac{SO_4 57,9xCl30,2xHCO_3 12,8}{Ca42,4xMg35,3(Na+K)22,3}$
16	17^k	20,0	100	$Q_{I}ap$	16–22,0 24–38 48–60 66–730 83–92	46,0	50–60 64–74 83–93	8,1	19,7	11,62	1,38	0,12	0,16	7,36	$M_{0,86}\frac{HCO_3 45,7\ SO_4 28,8xCl25,5}{Ca38,8xMg38,5x(Na+K)}$
17	18^k	21,1	100	$Q_{I}ap$	18–41,0 43–50,0 68–74,0 74–78,0	17,0	43–50 68–780	12,75	34,55	21,80	0,8	0,038	1,0	17,0	$M_{6,7}\frac{Cl83,2xSO_4 12,9xHCO_3 3,9}{(Na+K)79,5xCa11,1Mg9,4}$
18	19^k	-1,1	100	$Q_{I}ap$	43–50,0 68–75,0 75–79,0	16,0	43–50,0 66–79,0	5,3	21,3	16,0	1,4	0,09	1,24	19,84	$M_{2,7}\frac{Cl43,5xSO_4 33,4xHCO_3 23,1}{(Na+K)76,2Ca13xMg10,8}$
19	20^k	-21,1	100	$Q_{I}ap$	21,0–42,0 47–53,0 60–69,0 70–75,0 79–92	24,0	45–53 70–75 80–92	0,7	15,8	15,1	1,9	0,13	0,75	18	$M_{2,90}\frac{Cl67,9xSO_4 23,2xHCO_3 8,9}{(Na+K)60,1Ca21,7xMg18,2}$
20	21^k	-21,3	100	$Q_{I}ap$	0,0–23 42–47 58–85	27,0	43–48 61–71 80–90	0,0	12,2	12,2	4,9	0,4	0,52	14,04	$M_{6,6}\frac{Cl70SO_4 23,3HCO_3 6,7}{(Na+K)72,2Mg14Ca13,8}$
21	22^k	-22,0	100	$Q_{I}ap$	5,0–25,0 40–48,0 58–81	31	43–48 61–71 80–90,0	1,8	13,5	11,7	4,5	0,38	0,47	14,57	$M_{1,7}\frac{Cl76,8xHCO_3 16,3xSO_4 6,9}{(Na+K)51,4xMg265xCa22,1}$
22	23^k	-12,5	100	$Q_{I}ap$	21–37,0 50–83,0 90–99,0	34	50–60 75–85 89–99	6,38	12,76	6,38	1,2	0,31	0,7	23,8	$M_{1,57}\frac{SO_4 56,2xCl25xHCO_3 18,8}{(Na+K)54,2xCa28,9xMg22,9}$
23	24^k	-6,3	100	$Q_{I}ap$	12,5–38,0 60–67,0 73–83	29	30–36 60–67 73–83 92–99,0	12,5	37,0	24,5	1,25	0,1	0,39	11,31	$M_{0,56}\frac{HCO_3 61,7xSO_4 35,7xCl_{2,6}}{(Na+K)37,0xCa33,3xMg29,7}$
24	25^k	-7,5	100	$Q_{I}ap$	21,2–38,0 50–60,0 62–67,0 75–65,0 92–98,0	40	50–60 75–85 62–67 93–98,0	21,2	32,98	11,78	1,67	0,14	0,58	23,2	$M_{1,6}\frac{SO_4 45,6xCl30,0xHCO_3 24,4}{(Na+K)72,6xMg20,3xCa7,1}$

Table 3

General hydrogeological characteristics of water horizons and complexes

Name of water complexes	Maximum well flow rate, litres/sec	Special flow rate, litres/sec m	Water mineralisation degree, g/l	Chemical composition of water
Khvalyn water complex	3,01	0,28	1,1–2,07	Sodium chloride, sodium chloride-magnesium-calcium, sodium-sulphate-hydrocarbonate-sulphate-sodium-calcium
Khazar water complex	4,9	0,4	1,07–4,5	sodium-magnesium chloride-sulphate
Absheron water complex	1,0	0,076	1,1–1,84	Sulphate-chlorine-sodium-magnesium-calcium

Discussion and conclusions

The hydrogeological conditions of the Absheron Peninsula and the factors influencing its formation were determined based on the following local indicators:

• physical-geographic conditions, administrative location, climate (long-term, average monthly temperatures, precipitation, evaporation, humidity), hydrographic works, vegetation, and soil cover; geological structure (structural-graphic subdivisions, lithological composition, forms, thicknesses, etc.);

• geomorphological structure (mountainous and plain territories, their altimetric marks, etc.);

• hydrogeological conditions of the area (unconfined and confined waters, depth, discharge, chemical composition, mineralization, etc.);

• the thickness of the pressure and low-pressure water horizon in the East Absheron area is 20–46.0 metres. Low-pressure water is found in Nardaran-Zagulbinsky and Mardakan-Shuvelan sites, and pressure water is widespread in other sites, Gala-Dyubendinsky, Zira-Turkan, Bina and Govsan sites (Tab. 3).

In these areas groundwater is suitable for technical purposes:

• based on the results of preliminary assessment and earlier hydrogeological zoning, 12 promising areas were identified in 3 hydrogeological areas. Below are summarised results of hydrogeological investigations in these prospective areas (Tab. 4);

• it is proposed to continue hydrogeological studies periodically at all sites where exploitable groundwater reserves have been estimated (Yungmeister et al., 2023; Yungmeister, & Gasimov, 2021; Zhukov et al., 2023);

• as a result of investigations in East Absheron carried out by VES method, geoelectro-geophysical sections ρt, 2 Pichugin diagrams, comparative plots of VES curves and logging diagrams of 2 wells drilled by hydrogeologists were constructed. As a result of geophysical research carried out by VES method, geoelectro-geophysical sections of 20 ρt on the territory of Eastern Absheron, 2 graphs of determining the directions of geophysical unconformities along the path of the route by Pichukin method were obtained, a map on a scale of 1:50000 of the results of geophysical research works was made and suitable places for drilling of 31 wells with a depth of 50–100 m were determined;

• physical (granulometric composition, density, porosity, plasticity limits, etc.) and mechanical indicators of rocks (deformation regime, compression degree, resistance to shear and compression, etc.). This comprehensive analysis revealed the current hydrogeological conditions of the Absheron Peninsula, as well as natural and anthropogenic factors affecting its formation.

Table 4

Generalised results of hydrogeological studies of promising areas

Name of the area	Water quality indicator, g/l	Thickness of water section, m	Permissible level drop, m	Filtration coefficient value, m/day	Special flow rate, l/sec m	Exploitable reserves, th. m^3/day	Water utilisation
1. Bilgah water intake	1–1,1	32,6	26,46	1,24	0,15	1,57	For domestic technical purposes
2. Zagulba water intake	1,1–1,5	36,4	21,84	0,81	0,1	0,8	–"–
3. Mashtaga water intake	1,0–2,1	20,62	12,37	1,1	0,07	0,6	–"–
4. Mashtaga water intake	0,66–0.74	57,7	34,62	0,51	0,37	2,7	In all areas
5. Water intake in the north-west of Bina village	2,16–2,34	20,5	12,3	1,32	0,24	1,0	For domestic technical purposes
6. Water intake in the village of Bina	2,18–2,28	23,5	14,1	0,33	0,09	1	–"–
7. Shuvalan-Gala water intake	0,9–1,07	34,5	20,7	0,79	0,17	1,4	In all areas
8. Goshagovak water intake	2,3–3,0	43,2	25,92	0,54	0,14	2,1	For domestic technical purposes
9. Yeni-Gala Pirallahi water intake	1,07–1,10	23,4	14,04	3,8	0,32	3,5	" – "
10. Turkan-Zira water intake	1,37–2,6	29,6	17,76	0,5	0,22	3,6	" – "
11. Govsan water intake	1,7–3,0	35,83	21,5	2,06	0,27	6,6	" – "
12. Govsan -2 water intake	2,0–2,9	30,33	19,9	0,69	0,12	7,5	" – "
For domestic and technical purposes For drinking water						29,39 2,98	
Total						**32,37**	

Studying these factors in the territory allows identifying conditions for potential endogenous and exogenous geological events and implementing necessary preventive protective measures.

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СУЧАСНІ ГІДРОГЕОЛОГІЧНІ УМОВИ АПШЕРОНСЬКОГО ПІВОСТРОВА

Вступ. ***Апшеронський півострів є найбільш густонаселеним і екологічно забрудненим районом Азербайджанської Республіки. Бурхливий розвиток нафтової промисловості в цьому районі негативно вплинув як на море, так і на значну частину півострова. У цій статті розглядаються фізико-географічні умови, геолого-геоморфологічна будова і фізико-механічні властивості гірських порід з гідрогеологічного погляду. Метою дослідження є вивчення причин екологічного дисбалансу, виявлення факторів, що впливають на сучасні гідрогеологічні умови Апшеронського півострова. Гідрографічна мережа півострова складається з Каспійського моря, струмків, численних солоних озер, що живляться атмосферними опадами та нафтовмісними водами, причому озера мають значний вплив на клімат і екологічну ситуацію в цьому густонаселеному районі.***

Методи. ***Методи дослідження полягають у вивченні фізико-механічних властивостей зразків ґрунтів і гірських порід, відібраних із ручних колодязів і свердловин, з погляду інженерної гідрогеології, їх літологічного складу і потужності.***

Результати. ***Досліджено характеристики штучних озер, водосховищ, колодязів і свердловин Апшеронського півострова, а також його безнапірних і напірних водоносних горизонтів. Узагальнюючи дані про глибину, дебіт і хімічний склад підземних вод і оцінюючи фактори, які відіграють значну роль у формуванні гідрогеологічних умов території, встановлено причини підняття рівня підземних вод і запропоновано шляхи їх усунення.***

Висновки. ***За результатами досліджень уточнено сучасні гідрогеологічні умови на всій території Апшеронського півострова, а також природні та антропогенні фактори, що впливають на їх формування. На основі цих факторів можна прогнозувати ендогенні та екзогенні геологічні події та вживати відповідних превентивних захисних заходів. За результатами попередньої оцінки та раніше проведеного гідрогеологічного районування на 3 гідрогеологічних площах виділено 12 перспективних ділянок.***

Ключові слова: ***Апшеронський півострів, гідрогеологічні умови, екологічно забруднена територія, підземні води, артезіанські водоносні горизонти, фізико-хімічний склад.***

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні пропублікацію результатів.

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