Baku State University Journal of Earth Sciences & Environment **2025**, v 2 (3), p. 48-55

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

THE NATURAL AND ARTIFICIAL FACTORS ROLE IN UNDERGROUND WATERS FORMATION (ON THE EXAMPLE OF KARABAKH PIEDMONT PLAIN)

Gunay N. Huseynova

Baku State University, 33, Z. Khalilov str. AZ 1148 Baku, Azerbaijan

DOI: https://doi.org/10.30546/209805.2025.2.3.1010

Abstract

In the modern era the research, assessment and effective use of underground waters are the priority issues in solving the water problems. Among natural factors the geological-structural, geomorphological, hydrological and climatic factors play an exceptional role in the underground waters formation. Moreover the artificial factors influence is also one of the main factors in the underground waters formation. The article has been devoted to the research of the natural and artificial factors role in the underground waters formation of the Terterchay alluvial fan entering in the Karabakh piedmont plain. Within the Karabakh massif underground waters at 300-400 m depth are represented by 1 underground and 5 confined water-bearing horizons (aquifers). They have a common recharge zone and are hydraulically interconnected.

Keywords: geological structure, underground waters, confined waters, mineralization, chemical composition

*Corresponding author.

E-mail address: gunayhuseynova@bsu.edu.az (Gunay N. Huseynova)

1.Methodology and discussion.

The underground and above-ground water resources of the Republic of Azerbaijan are very limited. Since the use of the underground waters resources is growing every day it is important to research, re-evaluate and effectively use the conditions in which they are formed. Recently the solution of the problems connected with global warming and water deficiency has led to wider use of underground waters, since it is an ecologically more profitable and safe source of water.

The article has been devoted to the research of the recharge sources, formation conditions and the reserves of the underground and confined waters of the research area. The Karabakh piedmont plain is located in the southwestern part of the Republic of Azerbaijan, at the foot of the Lesser Caucasus and it is one of the parts of the Kura-Araks lowland. It is conditionally separated from the Ganja-Gazakh and Mil steppes by the Injechay and Gargarchay rivers. The territory borders with the Injechay river in the north, the Araz river in the south, the Kura river in the east and southeast, and with the piedmonts of the Lesser Caucasus in the west. It covers the territories of the Yevlakh, Barda, Terter, Agdam, and Aghjabedi administrative regions.

The Karabakh plain climate is characterized by moderately hot semi-desert summer and relatively severe dry steppe climate in winter. The amount of the atmospheric precipitations is not so great. All Karabakh plain territory is suitable for agriculture. The soils are slightly, moderately, and highly salinized. The sodium, sodium-sulphate alkaline soils and meadow alkaline soils are also widely distributed. The main water supply of the plain is carried out by the Upper Karabakh Canal (UKC), Terterchay, Khachinchay, Gargarchay, Injechay as well as underground waters extracted from subartesian wells. The geological structure of the plain has been formed by Mesozoic (Jurassic, Cretaceous), Paleogene, Neogene and Quaternary deposits [1,5].

Table 1.

Hydrothermal rivers indices of the Karabakh piedmont plain

Rivers	Watershed area, in km2	Length in km	Average annual discharge rate, in m^3/sec.
Kura		65	311 (Yevlakh)
Khachinchay	657	119	3.14 (Kalatag)
Terter	2650	200	22.5 (Magadiz village)
İnjechay	205	83	1.12 (Talysh channel)
Gargarchay	1490	115	1.42 (Agakerpu)

Underground waters of the alluvial fans of the Karabakh piedmont plain are formed in several water-bearing horizons. The influence of the EGC originating from the Mingechevir reservoir on the underground waters regime of the piedmont plain has been investigated on the basis of the network data of the Karabakh plain regime observation since 1947. It plays very special role in evaluation of the underground waters exploitation resources [2,3].

Within the research area underground waters at 300-400 m depth have been represented by groundwaters and 5 water-drive horizons having a common recharge zone and being hydraulically interconnected. The unique natural peculiarities, a variety of the lithological structure of the quaternary deposits, meliorative and irrigative-economic works have created complex hydrogeological condition in the Karabakh economic region. The groundwaters are distributed on the whole territory of the massif and are represented by various lithological composition. They are formed in the coarsely clastic rocks in the upper parts of the the powerful areas of the river alluvial fans therefore they create the favorable conditions for the surface waters infiltration at 70-80 m depth. While moving to the east the depth of groundwaters occurrence decreases up to 5-1 m. At Mil plain boundaries the groundwaters level fluctuates mainly at 1.0-2.0 m depth. The lithological composition of the water-bearing horizon consists of clay, clay loam, sandy loam, sandstone, pebble and bench gravel. Its thickness reaches up to 10-50 meters. Groundwaters are found at occurrence depth less than 1.0 m in some small areas. The filtration coefficient of the groundwaters horizon ranges within 0.16-93.2 m/day [2,4].

2. Properties of groundwaters

The groundwaters level in the area corresponds to the relief of the land surface and it is directed from the southwest to the northeast. The slope of the groundwaters flow in the area varies between 0.001-0.008 in the central part and decreases from 0.001-0.004 up to 0.0003 within the Mil plain. The underground waters are replenished by the water seeping from rivers, channels and irrigation water, condensation water, atmospheric precipitations, underground waters flow from adjacent plains and mountain zones as well as vertically flowing confined water. The various factors are influenced on the groundwaters level regime in the different areas.

Groundwaters level rises slightly in March-April and remains until August in the areas where irrigation waters and atmospheric precipitations predominate. After the finishing the irrigation there occurs a slight decrease due to the intense evaporation from mid-September to the end of October-November. The amplitude of the rise and fall of groundwaters varies between 0.8-2.0 m, depending on the rocks water permeability properties of the cover layer and the amount of the feeding water.

The comparison of the water level in the Kura river with the groundwaters level shows that groundwaters does not flow into the Kura river everywhere. The Kura river feeds groundwaters in some areas. The evaporation from groundwaters exceeds replenishment and the depth of groundwaters occurrence is less than 4 m in the warm months of the year. The replenishment predominate over the evaporation in the deep occurrences of groundwaters.

The occurrence depth in the semi-desertic and mountainous zones is several tens of meters. The general indicator of the occurrence depth in the Kura lowland as well as in the Karabakh plain is 3-5 m (Table 2).

Table 2.

The distribution areas in the occurrence depth of the groundwaters level in the Karabakh plain

Occurrence depth of groundwaters, in m	Distribution areas in the occurrence depth of the groundwaters level, in different years, in %				
	1930	1951	1976	2000	2016
0-1	7.0	6.5	1.15	6.6	6.5
1-2	0.0	20.47	16.35	26.0	28.4
2-3	13.5	15.8	23.25	12.3	16.3
3-5	20.5	29.53	12.36	5.2	4.8
5-10	22.2	16.9	13.78	23.6	22.4
more than 10	37.9	11.8	33.13	26.4	21.9

Groundwaters distributed in the investigated territory are distinguished by diversity according to the hydrochemical composition. Both fresh waters being suitable for use (mineralization level up to 1 g/l) and salt water being unsuitable for use (10–145 g/l) are distributed here (Table 3). The mineralization of groundwaters in the most plain areas was up to 0.5–1.5 g/l, and it did not exceed 1.0–2.0 g/l in the central and upper parts of the rivers alluvial fans in the piedmonts. Due to the conducting the works according to soils development and the melioration works, the groundwaters mineralization has decreased in the irrigated territories.

Groundwaters are found in deposits of the various genetic types on sloping piedmont plains and its chemical composition is also variable. The chemical analysis results of the water taken from observation wells along the Kura river are as an example. The springs popularly called “Black Water” (Garasu) flow below the alluvial fan of the Tartar river. In the past they created swamps in some areas.

Fresh groundwaters coming from the central and upper parts of the alluvial fan of the Terter river are very suitable for water supply and irrigation. Groundwaters are different in the chemical composition here. The hydrocarbonate type waters are distributed in a significant part of the piedmont territory. The sulfate type waters are found in the upper part of the Terterchay alluvial fan as well as in the Gargarchay and Injechay alluvial fans.

The mineralization increase is observed in the north-eastern and north-western directions along the alluvial fan of the Terter river. The chemical composition of waters in this direction changes from sulfate-hydrocarbonate to sulfate-sodium. After putting into production the UKC underground waters mineralization increased by 1-3 g/l. in the canal influence zone. After the construction and completion of the CDN the opposite regularity was observed due to the influence of the irrigation and washing. Presently underground waters mineralization is about 1-2, 2-3 g/l and their chemical composition - hydrocarbonate-sulfate, sulfate-hydrocarbonate-sodium, sodium-magnesium. The pH varies within 8.7-10.4.

Groundwaters occur at 3-5 and 6-10 meters depth along the Kursk plain. Here the main recharge sources of underground waters are seeping waters of the Kura river, irrigation waters and infiltration

of the atmospheric precipitations. Underground waters seeping usually occurs due to evaporation but in other areas – due to draining towards the Kura river.

3.Pressure waters

In the early 1990 the reference regime network was created to research confined waters regime on the plain but due to the financial difficulties this work was not completed. That is, the confined waters regime in the region has been studied only in the areas of the centralized or group water intakes in Barda and Yevlakh cities located on the alluvial fans of the Terter and Inja rivers as well as in wells located near the Mirzajafarli village of the Barda region. The research of the hydro-chemical and hydrodynamic regime of the confined water-bearing horizons was carried out in 3/1, 3/2 wells located in the centralized water catchment area of the Yevlakh city, in 1/2 wells located in the Malbinasi village, in 7/1, 7/2 wells located in the Zumyur village of the Barda city watershed area and in 679/2, 679 wells located near the Mirzajafarli village of Barda district. Over the years, regardless of the natural and artificial factors impact the piezometric levels of confined water have remained stable in the area of the Mirzajafarli village. The piezometric level of confined water in 1/2 and 1/3 wells located in the Malbinasi village was 4.19 and 4.64 m respectively in 1999.

Throughout the reporting periods the level in these wells has increased up to 4.08 and 4.48 m and the annual change amplitude has been 0.17-0.22 m. The same situation is repeated in 3/1 and 3/2 wells located on the territory of the gas station of the Yevlakh city.

The water samples, taken from observation wells where the centralized or group watershed regime was studied, had a total mineralization being close to 1.5 g/l. İn the reporting years there were not found pollutants in them.

As already mentioned the upper three confined water-bearing horizons refer to the Quaternary period but the fourth and fifth confined water-bearing horizons refer to the Absheron and Akchagil deposits, respectively.

The first confined water-bearing horizon has been exposed by wells in the center and in the east of the Karabakh plain piedmonts at 20-100 m depth, the thickness of the water-bearing horizons is 4-109 m. The depth of the horizon occurrence increases in the direction of underground waters movement but its thickness decreases. The rocks filtration coefficient is mainly 10-15 sometimes up to 38.7 m/day, water yield (discharge rate) in wells is 0.07-11.7 l/sec and the specific yield is 0.05-4.2 l/sec·m. The piezometric level is above the land surface (in the margins of the Terterchay and Khachinchay alluvial fans) and below its. The absolute value of the piezometric level fluctuates within 463 -“0” range.

The second confined water-bearing horizon covers a slightly smaller area in the piedmonts of the Kura river basin. The area occupying by its usually coincides with the distribution area of the first confined water-bearing horizon. This horizon doesn’t occur in the Gargarchay alluvial fan. The wells of the horizon have exposed at 70-270 m depth. Its thickness is 5 m in Khachinchay, 84 m in Injechay and 104 m in the Tartarchay alluvial fan. The filtration coefficient of the water-bearing rocks is 0.1-10.2 m/day, the wells yield is 0.16-13.8 l/sec, the specific yield is 0.06-2.1 l/sec·m. The absolute value of the piezometric level decreases up to 180-170 m in the southeast of Agdam and - up to 8-10 m towards the Kura river. The slope of the water runoff is 0.01-0.001.

The third confined water-bearing horizon has distributed along the right bank of the Injechay and everywhere except for the upper part of the rivers alluvial fan of the plain. Its occurrence depth from the piedmonts to the northeast increases from 115-150 m to 200-250 m and more. The horizon thickness is 20-51 m, the greatest thickness is confined to the middle part of the Terter river alluvial fan/

The infiltration coefficient of the water-bearing rocks is 0.5-11.6 m/day, the wells yield is 0.1-10.3 l/sec, the specific yieldis 0.08-0.85 l/sec·m. The absolute value of the piezometric level decreases towards the Kura river and it is 143-10 m. The slope of the water runoff is 0.008-0.004, the water level in the wells reaches 13-15 m from the land surface and it is free-flowing.

The fourth (Absheron) confined water-bearing horizon has distributed practically in the same area as the third horizon exposing at 135-400 m depth. It is not found on the left bank of the Kura river. The thickness of the water-bearing horizons is 20-40 m, the infiltration coefficient is 0.9-18.8 m/day, the rate of water discharge in wells is 0.6-23.2 l/sec, the specific discharge rate is 0.1-0.9 l/sec·m.

The absolute value of the piezometric level decreases from 150-140 m in the direction of the water movement and reaches 30-40 m on the Kura river banks. The slope in this direction decreases and it is 0.007-0.003. The water level in the wells is often 10-15 m above the land surface and it is free-flowing. However there is no gravity flow between Terterchay and Injechay.

The fifth (akchagil) confined water-bearing horizon has defined at 200-280 m depth in the central part of the piedmont plain and its depth has increased to the eastward, after which it has not been detected. While groundwaters and waters of the four upper confined water-bearing horizons are fresh, water in this horizon is salty and alkaline.

The infiltration coefficient of the water-bearing horizons is up to 4.5 m/day. The rate of water discharge in wells is 0.16-1.2 l/sec, specific discharge rate is 0.1-0.24 l/sec m, the absolute value of the level is 180-135 m, the slope of the water flow directed towards the Kura river is 0.01-0.005. The piezometric water level is at 2-3 m height above the land surface and being gravity-flowing.

Four water-bearing horizons of the Quaternary and Absheron period rocks can be considered as a unified hydrodynamic and hydrochemical complex. The total thickness of the water-bearing horizon in the most part of the territory is 50-100 m. The permeability coefficient is 100-2500 m/day depending on the thickness of the water-bearing complex. Groundwaters and waters of the four-confined horizons are suitable for use in the most areas, with the exception of small local areas and the outside parts of the alluvial fans.

Waters of the primary confined water-bearing horizon are fresh everywhere but there are found saline waters with mineralization of less than 1-5 g/l in the Terter and Khachinchay rivers interfluve and - even up to -15.5 g/l on the left bank of the Kura.

Waters of the secondary confined water-bearing horizon are also mainly fresh and they very rarely reach mineralization up to 1.9 g/l.

The total mineralization of the Tertiary confined horizon waters ranges from 0.2 to 2.6 g/l, and waters with low mineralization are found in the western border zone of the horizon between Terterchay-Khachinchay and Khachinchay-Kargarchay.

Waters of the Quaternary confined horizon are fresh and reaches up to 1 g/l in the most areas and rarely - up to 3.1 g/l. They occur in a small area on the Khachinchay river left bank - at the boundary of the horizon distribution. As mentioned above waters of the fifth confined horizon have high mineralization in the other areas, with the exception of the Khachinchay-Kargarchay area - up to 13.6 g/l.

According to the chemical composition fresh waters are hydrocarbonate, sulfate-hydrocarbonate, sometimes hydrocarbonate-sulfate and sulfate in all horizons and with mineralization over 1 g/l - sulfate.

For providing water needs of the rural settlements in the Yevlakh, Terter and Agdam districts the commercial water reserves have estimated at 95.6 thousand m3/day volume and approved for the group watersherd in the upper part of the Terterchay alluvial fan.

Conclusion:

1. The geological structure of the territory includes Cretaceous, Paleogene, Neogene and Quaternary deposits up to 300-400 m depth and only the Quaternary deposits have been studied.

2. As a result of hydrogeological investigations groundwaters and five confined water-bearing horizons have revealed in the territory. From these confined water-bearing horizons the first and second ones are considered suitable for water supply. It is more appropriate to use confined waters since it is well protected from pollution.

3. Groundwaters have revealed by an average of 20-31 m depth in the piedmonts, 2-5 m depth towards the Kura, sometimes less with an average effective thickness - 24.13 m, an average infiltration coefficient - 14.5 m/day and an acceptable water level fall - 14.5 m. I confined water-bearing horizon is 20-100 m; II confined water-bearing horizon -70-270 m; III confined water-bearing horizon -115-250 m; IV confined water-bearing horizon -135-400 m; Vst confined water-bearing horizon is exposed at 200-280 m depth.

4. The average effective thickness of I and II confined water-bearing horizons is 52.25 m, and the average infiltration coefficient is 6.7 m/day. Waters of the I, II and IV confined water-bearing horizons are fresh nearly everywhere (up to 1 g/l) whereas the waters mineralization degree of the confined water-bearing horizons III ranges within 0.3-2.8 g/l. The waters of the V confined water-bearing horizon have high mineralization (10.0-14.0 g/l) in the most part of the territory. According to the chemical composition fresh waters are hydrocarbonate, sulfate-hydrocarbonate sometimes hydrocarbonate-sulphate in all horizons. Fresh waters are also sulfate if the mineralization exceeds 1 g/l.

References:

[1] Imanov F.A., Alakbarov A.B. The contemporary changes of Azerbaijan water resources and its integration management// Baku-2017

[2] Mammadova E.A. Regime and balance of groundwater. Baku, “Füyüzat”, 2021, 148 p.

[3] Mammadova E.A. Meliorative hydrogeology. Baku, Laman Publishing House Polygraphy LLC, 2016, 268 p.

[4] Gulmamadov Ch.J., Tagiyev I.I., Kerimov V.M., Tagiyev A.Sh. Theoretical foundations of the prospecting and exploration of the underground waters deposits// Baku: ASUOI Publishing House, 2021. - p. 302

[5] Huseynova G.N Study of hydrodynamic and hydrochemical regime of subsoil waters in the debris cone Tartarchay. Bulletin of the Belarussian State Agricultural Academy Journal №3, 180-183, 2022.