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GROUNDWATER DEPLETION OF THE ARARAT ARTESIAN BASIN

G. A. Torosyan
Ministry of Energy Infrastructures and Natural Resources of the Republic of Armenia

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Underground waters along with the surface waters form the main water resources of Armenia. At the same time, the underground waters with their characteristics of formation, origin, transportation, dumping and accumulation greatly differ from surface waters. Today the supply of underground waters for water utilization doesn't differ much by its character from surface water providing. Providing of too much underground water utilization in Ararat artesian basin without estimation of water resources and permittable recession and water intake determination led to the exhaustion of underground water supplies, the fountaining zone reduction, decrease of spring cost and drainage. To solve the problem it is supposed to reduce the permissions for water utilization, to reduce and regulate water intake and to restaimate the utilization resources.

Key words: *Ararat artesian basin, groundwater, depletion, resource*

Introduction

Since the beginning of 2000 the centralized and massive utilization of Ararat artesian underground waters had started especially with their fountaining component through providing water utilization permits. It was realized without the estimation of underground resources and water intake measurments. It seemed that the water is allowed to be utilized not from the entrails but from an open reservoir. It means you can take as much as you want.

Such situation was created due to the ignoring the scientifically and legally justified circumstance of underground water as useful mineral and that their production is not regarded as exploitation of underground water mines which is fixed in RA Law of entrails and professional literature.

Conflict setting

Groundwaters together with surface waters form the main water resources of our country. At the same time the underground waters with their characteristics of formation, origin, transportation, dumping and accumulation greatly differ from surface waters. Today the providing of underground waters for water use doesn't differ much from the use of surface water by its character. In both cases, the same prerequisites are applied and the unique status of groundwater which is its being a mineral is never taken into account.

At present, water use issues of groundwater resources are regulated only by the RA Water Code. Under the same law, their location (mine site) before providing them with groundwater resources (mine) is not considered as mine and does not address geological exploration and inventory issues. Their implementation is a compulsory legislative requirement [1].

At present the issues of providing water utilization of groundwater resources are regulated by only the RA Water Code. By this Code the site of underground water resources (minerals) is not considered as mine (the place of entrail) before they are provided for water utilization and the issues on geological research and water supply estimation are not regulated. Doing these tasks is a legislative inquiry [1].

The current tragic situation of Ararat artesian reservoir occurred since the realization of massive water utilization permits (easily available water) on the basis of the Water Code of the RA thus ignoring the legal acts of the RA. On the basis of the latter the permitted water intake was realized which exceeded the reasonable limits (much water). The fountaining of the water (easily pumping water), low temperature 13-14 C^0 (good water) and the low cost of its natural use (cheap water) which

is currently 0,5 drams for 1 cubic meter but before it was cheaper for 5 lumas were the reasons of reducing the level of pressure waters and gradual reduction and drainage of all the previous intake constructions (springs, wells). These facts evidently witness that the runoff components in groundwater balance of Ararat artresian basin (expences and intake) began to exceed the income components (feeding), i.e. the natural resources. In this case not only the renewable resources but also the static supplies are being used. The actual capacity excess takes place over the permitted water intake and there is exhaustion of water horizons. The latest circumstance led to the reduction of national water supply capacity which is legally forbidden.

Research results

The exploitative sweet groundwater resources of Ararat artesian water basin (up to 1 g/l mineralization) were last estimated and confirmed in 1984 (Protocol N 9475 ГКЗ СССР since 25 april 1984) [2] and comprised 70 m^3/sec (2,2 billion m^3/year) from which 22 m^3/sec (0,7 billion m^3/year) was used for water intake of spring groups and 48 m^3/sec (1,5 billion m^3/year) for well water intake. The exploitative supplies were estimated for limitless period of time and by working 1455 exploitative wells. At the same time the drilling of each well will reduce its water resources and it will be necessary to realize restimation of the resources which is pointed out in the 2.8 point of the above mentioned protocole.

According to the admitted viewpoint (literature, regulations, instructions), the exploitative supplies of groundwater are the supplies, which, accounting the ecological needs, can be taken from the mine site in the case of accepted regime of exploitation with technically and economically estimated pumping structures thus preserving water quantitiy and quality during all the period of water utilization calculations. If we follow the logics of this concept, then it was not to be a depletion of Ararat artesian basin water resources by exporting 1,5 billion cubic meters water with 1455 water well holes keeping at the same time the expences of natural springs.

However, new well holes began to be opened with new operation since 1990 and especially 2000 and in 2016 [3] about 1795 well holes were operating for the purpose of exploitation with 64 m^3/sec or 2 billion m^3 total capacity. The production of water for more than 500 million cubic meter annually from the exploitative supplies confirmed for well holes led to current tragic situation.

As a result the fountaining zone in Ararat artesian basin reduced up to three times and almost all springs were dried the constant expense of which comprised about 30 m^3/sec, after which the water levels of underground waters began to reduce gradually, the pressure horizons began to exshaust and the expences of the rivers fed by springs decreased. The surface area of underground waters which have positive pressure reduced by three times reaching from 32760 hectare to 10706, Fig.1 [4]. In 1983 44 communities were situated in the fountaining zone and 60 percent of them fully or partially lost their irrigation or potable household underground water which was received from fountaining well holes [4].

As a result of pressure water level reduction currently a number of springs of Kulibeklu, Aknalich and Taronik groups of the river mouths of the Metsamor have disappeared. From the mentioned spring groups no water flow is noticed in all seasons of the year. If the springs with centralized outcome are dried (example, Taronik, Metsamor museum, Kulibeklu), then in the central parts of previously surface dumping rivers small lakes of 4-5 m depth are noticed currently which serve as natural well holes. With the help of water pumps the waters of these lakes are used for irrigation and technical purposes of water supply with the following quantity: Aknalich - 0.4 m^3/sec, Armenian nuclear power station of Taronik group springs (ANPST) – 0,8 m^3/sec [3]. In many areas which previously had had positive level of pressure waters currently 0,2-0,5 m below sea level is noticed for them (villages Aratashen, Apaga etc) [4]. In some sections the pressure had dropped to 9 m in the well holes. For example, in the well holes near the village Aknashen in 1971 the height of water fountain comprised 8,3 m, and in 2018 the water level was under the ground of 0,6 meters.

This catastrophic state of Ararat Artesian Basin is the consequence of the massive use of water for fish breeding. In general, Armenian experience is unique in world practice when groundwater is used for industrial fish breeding. Usually groundwaters are used massively for irrigation purposes. However, in all cases, it has resulted in the consumption or decline of water, drainage of groundwater wells and their sources. The examples are numerous: the USA, India, Australia, Saudi Arabia and others [5]. The water horizon of Ohallala of the USA (submarine waterfall horizon of highlands) is a water line stretching from South Dakota to the southern borders of Texas. As a result of irregular irrigation during 60 years the watercourse has completely dried up. Saudi Arabia was a major wheat exporter in the world in the 1980s and 1990s due to the use of groundwater. Today these water courses are completely empty in Saudi Arabia. The US NASA experts have discovered that, due to the short term exploitation, 21 of 37 major US aquifers have reached the critical point of exhaustion.

A typical classical example of the depletion of groundwater resources is the precedent of groundwater depletion and drainage of carbonated waters and cavern springs in Ras Al Ain in the Syrian Khabur River basin. Here groundwater production has taken place without taking into consideration the requirements necessary for their study, reasonable exploitation and maintenance.

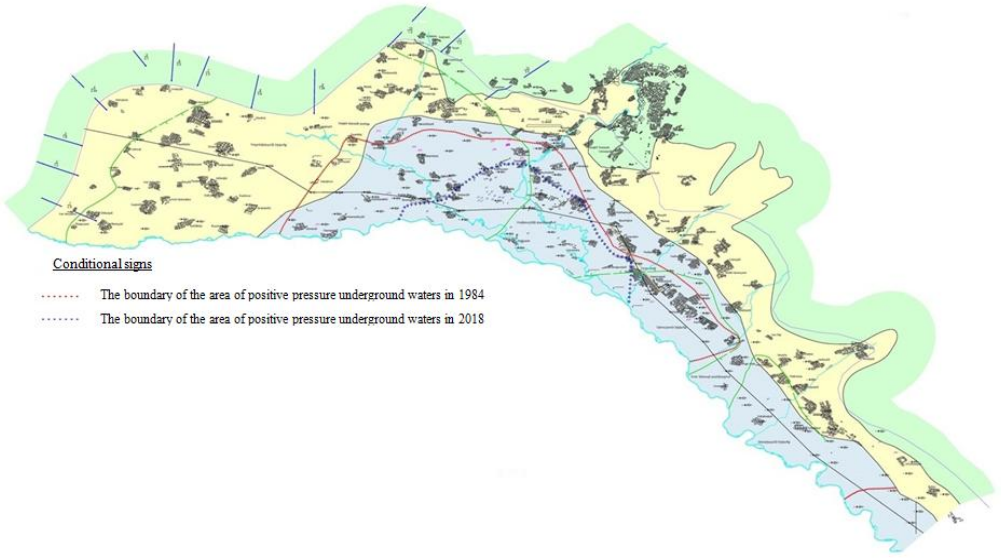

Figure 1. The map of fountaining zone of Ararat artesian groundwater

There were more than 300 springs till 2000s, among them were 17 powerful voccules and the cost of each fluctuated within 3-7 m^3/sec. The summative cost of the springs reached up to 45 m^3/sec - 100 m^3/sec.

The costs of these springs were constant till 1980 and it was possible to consider them as renewable and natural resources. The lands of Hasake and Der Eir Zore in Syria were irrigated with spring waters. Underground waters has begun to be produced from ten thousand (from about 40 thousand) well holes from the same basin with uncontrollable irrigattion purpose. The result was catastrophic and during 20 years the flow of all these drinking springs stopped and they turned into drainless lakes. Afterwords during five years all the lake-springs completely dried up till the bed. Currently the process of underground water depletion is going on and the underground water level recesses for 0,5 m annually.

All the pemissions for water utilization has been given without hydrological researches and confirming underground waters in Ararat artesian basin since 2000. The principle of scientifically proved and practically applied method and methodology was roughly violated. The sources of feeding and renewing of underground waters, the radiuses of feeding of water intake well holes and their

influences, the interrelated influence among neighboring water intakes, the boundary and edge conditions of pressure water courses, the coefficients of water conductivity and level conductivity and filtration parameters were not determined. It is known that during the exploitation the inflow of non condensing waters happens from neighboring water courses which makes the qualitative characteristics of waters worse. The predictions on water quality changes were not realized. The interactions of different water courses, water intake well holes and also underground and surface waters were not estimated. The exploitation was being done by inefficent schemes of well holes as a result of unfair water utilization.

Important characteristics for underground waters are 1) water amount in water courses 2) water amount which inflows into the water course in natural conditions 3) water amount which can be produced by efficient water intake constructions from the water courses from the technical and economical viewpoint.

So, if for perspective estimation of utilization of other useful minerals, oil and gas only one concept as «useful mineral resource» is enough, then the latter can not completely characterize the opportunities of efficient exploitation of underground waters. That is why in hydrogeology, except for the notion of «underground water supply», ther term of «underground water resource» is also used which determines the feeding of water courses. Underground water supplies and resources are subdivided into 1) natural, 2) artificial, 3) inclusive and 4) exploitative.

Under natural (dimensional) resources we understand the gravitation water amount condensed in cracks and pores of watercourse rocks. In no pressure water courses the water amount of fluctuation zone and gravitation water amount situated under the natural level fluctuations are divided which is called regulated supply. The elastic resources are also considered to be the natural resources of pressure cources. By the latter we understand the amount of those waters which is possible to produce during the level reduction on the basis of the elastic properties of rocks and water courses. Natural resources have capacity measurments.

Natural resourses (or static resources) - water course which is the water amount occurred as a result of seepage from atmospheric precipitations, water cources above and below the rivers and from the nearby territories in natural conditions. Natural resources are equal to the sum of inflow components of the given water course. They are expressed by cost units.

Artificial resources – the water amount formed as a result of seepage from irrigation in the water course and dams of artificial feeding.

Artificial resources – water amount occurred as a result of filtration losses from irrigated fields, canals, reservoirs and also as a result of artificial feeding.

Inclusive resources – water amount inflowing the water course from neighboring courses and other water bodies.

The estimation of exploitative water resources has the primary significance for installing water intake holes.

The exploitative supplies of underground waters are generally connected with other resources and supplies with the following balance [6]

$$Q_{ex} = \alpha_1 Q_b + \alpha_2 \frac{V_b}{t} + \alpha_3 Q_a + \alpha_4 \frac{V_a}{t} + Q_g$$

where Q_{ex}– the exploitative resources m^3/daily, Q_n and Q_a – natural and artificial resources correspondingly m^3/daily, V_n and V_a – natural and artificial resources correspondingly m^3, Q_g – inclusive resources, m^3/daily, t – time during which the exploitative resources are intended to be, α_1, α_2, α_3, α_4 – the coefficients of correspondingly natural resources, natural supplies, artificial resources and artificial supplies.

Experts have different opinions about the concept of groundwater depletion. This issue is not discussed here, but, in my opinion, it is necessary to distinguish two notions: (1) underground water depletion and (2) the depletion of the exploitative underground waters.

By saying underground water depletion all the cases connected with the reduction of natural and/or artificial resources should be understood which are connected with the exceeding of water costs to feeding. The reason for groundwater depletion can become the change of feeding conditions and groundwater exploitation.

By saying the depletion of exploitative underground water resources the case should be understood when the production exceeds the estimated exploitative resources.

The indicator of groundwater depletion is a continuous level reduction process that leads to a reduction in natural resources (gravitation - non-pressure horizons and elastic-pressure horizons). An important role in groundwater depletion is devoted to the intake and drainage structures.

Until now we have no response to the question what resources the groundwater supplies that are extracted in Ararat artesian basin are provided by. If we follow the structure of the formula, we will assume that the exploitative resources of fountaining zone are formed according to the elastic resources. The latters are not classified as resources and do not have the ability to recover. In the water course horizons the elastic regime of groundwaters is formed according to water and rock compression. Its dynamics is very complex and depends on many factors. In case of exploitation of elastic supplies by unlimited time it will definitely be exhausted.

In Ararat artesian basin only the fountaining component (which is economically profitable) is exploited from the elastic resources. In this case if $t\ldots\neq\infty$, then the second member of the balance formula will become zero and thereby the fountain waters will be consumed.

When this unlimited time will come it is still unknown. However, it is already clear that we have entered a time period that leads to the consumption of fountaining water resources. The vivid evidence of this is the fact that the fountaining has stopped in one third of the well hole fountaining area. Still it is not clear what time period is needed to obtain a certain elastic regime in a particular water horizon. For example, theoretically how much time will be needed after dewatering Ararat artesian basin to renew or restart the undisturbed regime with all its criteria.

At the beginning of 1980s studies to determine the age of groundwater circulation were conducted in Sevan basin in Armenia [7]. The method of isotope exposure (hydrogen isotope -D, oxygen isotope - O^{18}, carbon isotope - C^{14} and helium) has been applied. The Artesian basin of Sarukhan is situated in the basin of Lake Sevan which is very similar to Ararat artesian basin with its hydrogeological structure, origin and chemical composition of waters. By the results of isotopic research the age of groundwater circulation in Sarukhan's artesian basin pressure horizons has been estimated for about 500 years. This means that water pressure in the pressure horizons occurs during 500 years. Sweet water of 14000 years has also been encountered in Sarukhan basin.

Comparing Sarukhan and Ararat artesian basins, it can be stated that the recovery of undisturbed water regime of Ararat artesian basin will take at least 500 years.

The water course rocks of Ararat artesian basin (intermountain fields) have high water conductivity and involvement of dumping water to the depression zone during the exploitation of water intake structures. The depression funnel is about 530 square kilometers only in Armenia [3].

Generally, for estimation the exploitative resources of artesian basins the value of the module of groundwater exploitative resources is an important criterion*[1]. This criterion also serves as a

[1] By the module of the exploitative water resources we understand water cost l/sec which is possible to get out from 1 sq/m water surfac

specific indicator. That is to say, its dimension if reaches a certain unacceptable, disturbing limit during operation will be disconnected between the hydraulic capacity and exploitation of the water.

According to these conclusions, let's see how Ararat artesian groundwater exploitation was changed from 1980 to 2018. In 1980 it was 40 l/sec km^2 6] and in 2000-2010 it was 60 l/sec. km^2 reaching 1000 l/sec. km^2 at some territories. This means that groundwater extraction has increased from 1.5 to 50 times in 35 years. Since the increase was only due to natural (elastic) resources of fountain waters, it is evident that only natural resources are involved in the formation of exploitation supplies. In this case, the depletion of exploitation resources is taking place.

Conclusions

1. The renewing natural (dynamic) resources of Ararat artesian basin are consumed. It does not manage to renew. It is not known how long the undisturbed regime will continue. It is a complicated task still unsolved. It can take hundreds and thousands years.
2. The water intake is realized due to natural (static) resources from Ararat artesian basin which is constantly decreasing. Besause of complicated geological structure no researcher and research group could manage to estmate correctly the size of the supply of the exploitative resources of Ararat artesian basin.
3. The depletion of water courses of Ararat artesian basin takes place.
4. The permission of any new water intake by geometric progression order will fasten the process of depletion of water courses and decrease of water supplies.
5. The groundwater supplies of Ararat artesian basin were last estimated in 1983. 40 years have passed. According to the Soviet Period rules and regulations the supplies were confirmed for 25 years term [8]. Afterwords it was necessary to restimate those supplies: the same is required by RA Government 2012 November 22 №1480-N decision. According to the last decision the supplies should be restimated in case if there is a change in hydrological and ecological situation (all the springs were dried up and the fountaining zones and waters had been reduced).
6. All the data concerning the water supplies of Ararat artesian basin are outdated and their citing is professionally wrong. Now the Ararat artesian basin is not the same that has been 40 years before, all the hydrological and ecological parameters have been distorted.
7. It is confirmed in all the previous and current regulations that new water intake is not permitted if it is already being done. The water supply restimation should newly be done.
8. For the purpose of fishing industry or irrigation in the case of new well holes and new water intake the expences of water supply well holes for many settlements and objects will decrease or they will dry up. By this stage the depletion process of not fountaining pressure water courses will start. The new, unsecured water intake on the bank of the Metsamor (Sev Jur) will lead to the drying of the Metsamor which has natural flow.
9. The current capacity of underground water supplies of Ararat artesian basin is obvious. Now there is not so much water to provide the operation of those well holes.
10. It is necessary to stop the permissions of new water intake and to regulate the current water intake if we don’t want to lose the remaining water resources in Ararat artesian basin. After it will be late. Our next generation will say – They seemed to think about only fish eating.

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Գ.Ա. Թորոսյան
ՀՀ էներգետիկ ենթակառուցվածքների և բնական պաշարների նախարարություն

Ստորերկրյա ջրերը, մակերևույթային ջրերի հետ միասին ձևավորում են Հայաստանի հիմնական ջրային ռեսուրսները: Միաժամանակ ստորերկրյա ջրերը իրենց ձևավորման, առաջացման, տեղափոխման, բեռնաթափման և կուտակման առանձնահատկություններով խիստ տարբերվում են մակերևույթային ջրերից: Այսօր ջրօգտագործման համար ստորերկրյա ջրային ռեսուրսների տրամադրումը օգտագործման իր բնույթով չի տարբերվում մակերևույթային ջրերի տրամադրումից: Արարատյան արտեզյան ավազանում ստորերկրյա ջրերի ջրօգտագործման չափազանց շատ թույլտվությունների տրամադրումն, առանց ստորերկրյա ջրերի պաշարների գնահատման և թույլատրելի իջեցման ու ջրառի չափի որոշման հանգեցրել է ստորերկրյա ջրերի պաշարների հյուծմանը, շատրավանող գոտու փոքրացմանը, աղբյուրների ծախսի նվազմանը և չորացմանը: Հարցի լուծման համար առաջարկվում է կրճատել ջրօգտագործման թույլտվությունների տրամադրումը, կրճատել և կանոնակարգել ջրառը, իրականացնել շահագործական պաշարների վերագնահատում:

Բանալի բառեր. Արարատյան արտեզյան ավազան, ստորերկրյա ջուր, հյուծում, պաշար:

ИСТОЩЕНИЕ ПОДЗЕМНЫХ ВОД АРАРАТСКОГО АРТЕЗИАНСКОГО БАССЕЙНА

Г.А. Торосян
Министерство энергетических инфраструктур и природных ресурсов РА

Вместе с поверхностыми водамы подземные воды состовляют основные водные ресурсы Армении. Одновременно, подземные воды со своимы формированием, образованием, транзитом, разгрузкой и аккумляцией строго различаются с поверхностными водамы. Сегодня процесс видачи разрешений на водопользование для подземных вод по своему характеру не различается от выдачи разрешений на пользование поверхностных вод. Предоставление чрезмерно многое разрешений водопользования подземных вод Араратского артезианского бассейна, без подсчета запасов и определений допустимых норм водвозабора и понижения, привели к

истощению запасов подземных вод, уменьшению фонтанирующей зоны, понижению расходов родников и засушению. Для разрешения проблемы предлагается уменьшить предоставления разрешении на водопользование, сократить и регулировать водозабор, осуществить переоценку эксплуатационных вод.

Ключевые слова: Араратский артезианский бассейн, подземная вода, стощение, ресурсы.

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