

Transboundary Aquifers of Azerbaijan: Current Conditions, Challenges and Mitigation Possibilities

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ABSTRACT

This study aims to describe current status of transboundary groundwaters in Azerbaijan. Fourteen out of eighteen aquifers in the territory of Azerbaijan Republic are transboundary. Majority of surface water courses and part of groundwaters from Georgia and Armenia have natural tendency to flow towards the territory of Azerbaijan.

Average annual rates of surface run-off and potential groundwater sources are approx. 31-32 billion m³ and 9 billion m³, respectively.

In mountainous areas, groundwater is basically found in the areas of weathering and tectonic faults. Piedmont and intermountain troughs are much richer in fresh and low-mineralised groundwater. The lowlands of the Republic typified for unfavourable hydrogeological conditions.

No serious and critical problems exist between Azerbaijan and the neighboring countries in respect of the use of transboundary groundwaters. The main problem is that the rivers Kura and Araz (with their tributaries), as the most significant recharge sources of groundwater, are heavily contaminated in the territory of Georgia and Armenia i.e. the wastewater from industrial and domestic sources as well as irrigation waters containing chemical infiltrates are discharged into the rivers almost without any treatment. These rivers and their tributaries are used for disposal of irrigation waters contaminated with. Even in the territory of Azerbaijan, such contamination is enhanced by discharge of various contaminants. Local contamination of transboundary groundwater is also a matter of concern.

The authors propose several mitigation measures including but not limited to independent monitoring of river and groundwater sources under supervision and direction of international organizations, such as UNESCO, IAH, IAHS etc; comprehensive study of the conditions of recharge, chemical and biological content of groundwater sources, considered as vulnerable due to the impact of contaminated rivers; preparing an action plan for restriction contamination process; developing a scheme for integrated use of water resources in aquifers; ensuring compliance with Helsinki Convention 1992 by OSCE member-countries; technical modernization of water treatment plants and avoidance of disposal of untreated wastewater into the rivers; constructing drainage facilities and well as plants for entrapment and neutralization of infiltrates in heavily contaminated irrigation waters.

Keywords: aquifer, groundwater contamination, piezometric levels, mitigation.

1. INTRODUCTION

Located in the South Caucasus, the territory of Azerbaijan plays a role of transit land for surface and ground water flowing from the Mountain Ranges of the Greater Caucasus and the Lesser Caucasus down to the Caspian Sea. Groundwater resources are limited and unevenly distributed across the country. Main stock of groundwater is cumulated in piedmont sedimentary troughs. Significant parts of rural settlements situated downstream of the main transboundary rivers of Azerbaijan, Kura and Araz, meet their minimum water supply needs using untreated water from rivers, irrigation canals and even drain lines. The Kura River is one of the three existing water supply sources of Baku. In the territories of Georgia and Armenia, the Kura and Araz rivers are exposed to heavy contamination, which in turn impacts groundwater sources. It is necessary to prevent contamination of surface and ground water resources in the catchment areas of the Kura and Araz rivers, and to achieve integrated use of water resources in river basins.

2. OBJECTIVE

The purpose of this study is to disclose problems related to transboundary groundwater sources of Azerbaijan outlining the current conditions of existing aquifer systems, the quality of groundwater and

the status of their contamination. Comprehensive study of the current status of transboundary groundwater sources encouraged the authors to propose a number of mitigating solutions.

3. CURRENT STATE OF TRANSBOUNDARY GROUNDWATER RESOURCES

From geological-structural point of view, the territory of Azerbaijan Republic is represented by the Greater Caucasus (Fig.1 – A), the Lesser Caucasus (Fig.1 – B) Mountain Ranges and the Kura-Araz Lowland (Fig.1 – C) lying between these two mountain ranges. Altogether there are 18 hydrogeological basins, of which 14 have immediate borders with neighbouring countries (Fig.1):

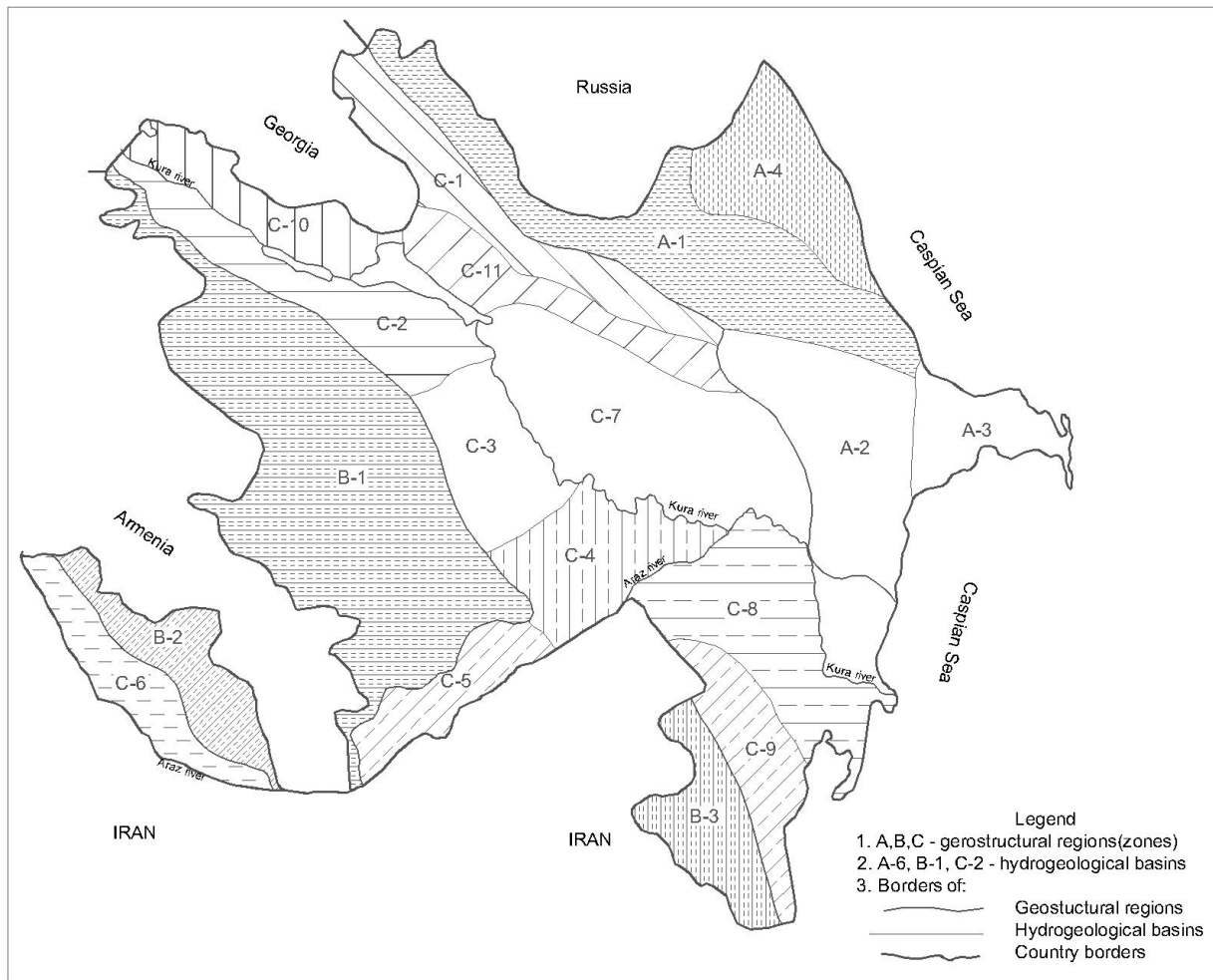


Figure 1. Structural-hydrogeological zoning scheme of Azerbaijan

With Georgia - Gyanja-Gazakh (Fig.1: C-2), Alazan-Eyrichay (Fig.1: C-2), Jeiranchel (Fig.1: C-10), Ajinour porous-stratal water basins (Fig.1: C-11) and partly the Greater Caucasus porous-fractured water basin (Fig.1: A-1);

With Armenia – Nakhchivan porous-stratal water basin (Fig.1: C-6), the Lesser Caucasus porous-stratal water basin (Fig.1: B-1) and Nakhchivan porous-fractured water basins (Fig.1: B-2);

With Iran – Nakhchivan (Fig.1: C-6), Jabrail (Fig.1: C-5), Mil (Fig.1: C-4), Mugan-Salyan (Fig.1: C-8), and partly Lenkoran porous-stratal water basins (Fig.1: C-9); porous-stratal water basins of the Lesser Caucasus (Fig.1: B-1) and porous-fractured water basins of *Mountainous Talysh* (Fig.1: B-3).

With Russia – the Greater Caucasus porous-fractured water basin (Fig.1: A-1) and Samur-Gusarchay porous-stratal water basin (Fig.1: A-4).

Due to downstream position of Azerbaijan's territory, huge volumes of surface water and part of groundwater from Georgia and Armenia have natural tendency to flow towards the territory of Azerbaijan. The territory of Azerbaijan plays a role of transit country for flow of surface waters and groundwaters from the Greater and the Lesser Caucasus Mountains into the Caspian Sea.

3.1. Aquifer systems

The mountain structures of the Greater Caucasus and the Lesser Caucasus are composed of Meso-Kainozoic and Palaeo-Kainozoic rock formations, respectively. Thick weathered, fractured rock formations and intermountain troughs with soil content of alluvial and fluvioglacial sediments are specific features of both mountain ranges. A distinguishing geological feature of the Azerbaijani part of the Greater Caucasus is higher prevalence of sedimentary deposits. The layers composed of fractured and Karstic formations are much richer in water reserves, whereas volcanogenic and intrusive rock formations have lower water content. Natural groundwater discharge locations / springs with approximate yields of 5-10 l/s are seen at the foothills. The springs with flow rates of 60-100 l/s are encountered mostly in the areas with karstic limestone rocks (Alekerov et al., 2008). Confined and unconfined aquifers have been penetrated by exploratory wells with depths varying from 40-50 to 200-250 m. (Table 1).

Table 1. Several hydrogeological parameters of aquifers

Geological-structural region	Surveyed depth, m	Aquifer	Groundwater level relative to ground surface, m	Flow rate, l/s	Permeability of water bearing strata, m/day
Mountainous Zone of the Greater Caucasus	200-250	unconfined	0,5-57	0,8-5,5	0,01 - 14,2
		confined	+14-8	0,8 - 10	0,01 - 22
Mountainous Zone of the Lesser Caucasus	200-250	unconfined	0,1-89	0,1-4,2	0,01 - 9,1
		confined	+12- 55	0,8 – 12	0,01 - 25
Kura-Araz Lowland	350-400	unconfined	0,2-150	0.06-57	0,006 -150
		confined	+50-81	0,01-98	0,01 - 246

Piedmont and intermountain troughs (Fig.1 –C) forming the Kura-Araz lowland are considered to be basins of porous-stratal waters and are rich in fresh and low-mineralized (up to 3 g/L) groundwater. They are formed by confluent fans of alluvial and alluvial-dealluvial sediments. Effective thickness of such sedimentary layers reaches 300-500 m, and seldom 1000-1500 m (Listengarten, 1987). All of these basins contain one unconfined and several confined aquifers. Occurrence depth of non-artesian aquifers varies from 60-80 meters at foothill parts of alluvial fans down to several centimeters at discharge zones. Confined aquifers lie further downstream of the contact zone of parent rocks and alluvial sediments. Top of confined aquifer can be penetrated at depths varying from 10-20 m up to 110-300 m. Yields of springs are generally high (Table 1.), roughly varying from 0,1-0,3 up to 15-20 l/s, and rarely reaching 200-250 l/s (Alekerov et al., 2008).

Scanty groundwater sources within the boundaries of Jeiranchel and Ajinohur basins are associated with local confined structures. Hydrogeological conditions of the lowlands composed of continental marine sediments are unfavourable.

3.2. Water resources

Average annual volume of surface water resources of Azerbaijan is estimated to be approximately 31-32 billion cubic meters, over 70% of which is formed beyond the country borders. Average annual volume of potentially usable fresh and low-mineralized groundwater in Azerbaijan is approx. 24 mln m³/day. Contribution by transboundary basins is approximately 80 percent. Significant recharge sources of transboundary groundwater resources are located within the borders of the country.

Annual groundwater production till 1980s and between 1980 -1990 was 2.5-2.9 bln m³ and 1.3-1.5 bln m³, respectively. Over recent years, however, annual groundwater production has increased again up to 3,0-3,5 billion cubic meters.

3.3. Groundwater quality

Groundwater in the mountainous zones is of drinking quality with calcium-hydrocarbonate content. Fresh and low-mineralized waters are widely spread in *piedmont troughs* depending on specific features of their geological structure, inflow rate, and the discharge conditions of the aquifers. In the lowlands, however, fresh waters are shifted by saline waters. Groundwater resources within Alazan-Eyrcihay and Samur-Gusarchay plains are of good quality. Fresh waters seldom occur in Jeiranchel and Ajinour plains, while saline waters with higher TDS content (50-70 g/l) are rather extensive. Groundwater in the lowlands is much saltier. TDS content varies between 100-200 g/l (Alekperov et al., 2008).

4. MANAGEMENT AND MONITORING OF GROUNDWATER RESOURCES

All water structures (e.g. rivers, aquifers etc.) in the territory of Azerbaijan are owned by the State. All legal and natural entities have the right to consume groundwater. The organizations involved in management of water resources are *Azersu* Joint Stock Company (JSC), which supplies water for drinking and other household purposes and *Melioration and Water Industry* JSC, which is in charge water supply for agricultural purposes. The Ministry of Ecology and Natural Resources carries out groundwater investigation, monitoring and coordinates arrangements associated with groundwater use.

Groundwater monitoring system has been valid since 1940s and 1950s. The monitoring system, composed of 900 Nos boreholes, draw wells, kahrizes (horizontal tapping) covers all hydrogeological regions incorporated in piedmont troughs and lowlands. Due to land reforms some of the monitoring sites happened to be parts of private lands and this lead to problems associated with maintenance and monitoring. Many observation wells have collapsed and become unfit for further investigation purposes.

5. PROBLEMS

There are no serious and critical problems between Azerbaijan and the neighboring countries in respect of the use of transboundary groundwaters. The major problem, however, is that the rivers Kura and Araz (with their tributaries), being the most significant recharge sources of groundwater, are heavily contaminated in the territory of Georgia and Armenia.

In the territory of Georgia every year around 330 billion cubic meters of contaminated water is discharged into the Kura River and its tributaries without any treatment. The Kura River's right

tributary Akstafachay River (flowing through Armenia) contains chemical dye, oil products, phenol, ammonia nitrogen and other contaminants that are discharged into the river together with wastewater. The rivers Alazan and Iori (left tributaries of the Kura River) also enter Azerbaijan already containing contaminants discharged in the territory of Georgia. While crossing the borders of Azerbaijan, the Kura River already contains oil products, phenols, and other contaminants in volumes exceeding admissible norms by 2-6 times depending on periods: phenols 3-20 times, copper 7-14 times, sulfate 2-3 times. In the territory of Azerbaijan, contamination is enhanced by agricultural pollutants, wastewater discharged from industrial premises and cattle farms as well as via local tributaries (Alekperov et al., 2006).

Araz, Azerbaijan's second biggest river in terms of length and flow rate has huge contamination concerns. Left tributaries such as Razdan, Arpachai, Okhchuchai etc. of the Araz River contain hazardous substances (nitrite nitrogen, ammonia nitrogen, heavy metals and other pollutants exceeding the sanitary norms dozens of times), which come from Armenia with water flow. Volume of annual wastewater disposal into the Araz River in the territory of Armenia exceeds 350 mln m³. In the periods of huge disposals, Armenia discharges highly contaminated wastewater into the Okhchuchai River, which flows into the Araz River making it red-brown and almost black. The red-brown liquid contains high concentration of aluminum, zinc, manganese, titanium, bismuth and other components. After the confluence of Okhchuchay with Araz River, microflora content of the river is reduced by 65-80%. The main reason for this situation is the lack of effective drainage system, treatment facilities as well as technical insufficiency of existing plants in most towns and settlements of not only Georgia and Armenia, but also Azerbaijan. Therefore, in most residential areas wastewaters originating from households are discharged directly into rivers.

In huge parts of the lowland, subsoil and aeration zones are exposed to natural pollution and salinization. Salinization rises sharply in poorly drained and drainless areas. Salinization rate in irrigated areas ranges from 0.25% to 1-2%.

Groundwater pollution of regional scale has not observed in Azerbaijan. Pollution is of domestic, industrial and agricultural nature. As already note, the main factor causing domestic pollution is the lack of effective drainage system and treatment facilities in most communities. Domestic wastewater is being disposed into the rivers, the sea, natural or manmade pits. Groundwater pollution is caused by infiltration of contaminated river water or migration of chemical agents via the zones of aeration. For instance, high concentrations of aluminum, iron, phenol, high as well as nitrites, nitrates, ammonia and sulphates were encountered in groundwater at the sludge pit of Ganja aluminum plant. Nitrites, nitrates, ammonia and sulphates are also observed in higher concentrations. Groundwater sources in occupied lands of Azerbaijan also undergo contamination due to discharge of entire wastewater from Khankendy and Askeran towns into the rivers, which feed the aquifers in the immediate vicinity of groundwater recharge sources.

Groundwater contamination with agricultural contaminants is observed mostly around fertilizer storages. Groundwater contaminants here include nitrate, nitrite and phosphate, which exceed admissible rates by 2-5 times. Concentrations of nitrites and nitrates in irrigable lands do not exceed the admissible norms, while around cattle farms such concentrations may reach 10-19 mg/L and 12-145 mg/L, correspondingly. Evidences of bacteriological pollution of groundwater have been recorded in irrigable areas, cities, cattle farms and near wastewater treatment plants.

Another problem of transboundary nature is natural transformation of river banks of transboundary rivers Araz (Iran) and Samur (Russia), though it is not reflected significantly in the conditions of groundwater under riverbeds. However, with certain states it is possible to balance existing conditions.

6. MITIGATION POSSIBILITIES

A number of solutions can be proposed for mitigating above problems. These include but are not limited to:

- organising and maintaining independent monitoring of river and groundwater under supervision and direction of international organizations, such as UNESCO, IAH, IAHS etc.

- carrying out a comprehensive study of the conditions of recharge, chemical and biological content of groundwater sources, considered as vulnerable due to the impact of contaminated rivers;
- preparing an action plan for restriction of contamination process;
- developing a scheme for integrated use of water resources in aquifers;
- ensuring compliance with Helsinki Convention 1992 by OSCE member-countries;
- taking steps for technical modernization of water treatment plants and avoiding disposal of untreated wastewater into the rivers, at least, in large cities and settlements;
- constructing drainage facilities;
- building facilities for entrapment and neutralization of infiltrates in heavily contaminated irrigation waters.

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Over the last 10 years, owing to various programmes and projects supported and implemented by UNDP, UNESCO, OSCE, NATO and other international organizations, progressive work has been done in respect of reduction of the scale of degradation in the catchment areas of the Kura, Araz and other rivers of the South Caucasus; coordination of investigations and activities undertaken by the countries located along the catchment areas; integrated use of transboundary water resources etc. The authors of this article wish to thank all contributing organizations for their challenging and laborious efforts. Although outstanding issues are not easily solvable, harmonisation of relevant approaches and solution methods becomes apparently evident during implementation of each and every programme.

The authors of the article have been steadily involved in implementation of similar programmes by preparing consolidated reports for Azerbaijan and the catchment areas of the Kura and Araz rivers. The authors are gratefully prepared to share their knowledge and expertise for such a noble and necessary mission.

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