EU4Environment in Eastern Partner Countries:
Water Resources and Environmental Data (ENI/2021/425-550)

TRANSBOUNDARY GROUNDWATER SURVEY 2023 – Armenia and Georgia

Funded by
the European Union

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ABOUT THIS REPORT

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Owner and Editor: EU4Environment-Water and Data Consortium

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July 2024

ABOUT EU4ENVIRONMENT – WATER RESOURCES AND ENVIRONMENTAL DATA

This Programme aims at improving people's wellbeing in EU's Eastern Partner Countries and enabling their green transformation in line with the European Green Deal and the Sustainable Development Goals (SDGs). The programme's activities are clustered around two specific objectives: 1) support a more sustainable use of water resources and 2) improve the use of sound environmental data and their availability for policy-makers and citizens. It ensures continuity of the Shared Environmental Information System Phase II and the EU Water Initiative Plus for Eastern Partnership programmes.

The programme is implemented by five Partner organisations: Environment Agency Austria (UBA), Austrian Development Agency (ADA), International Office for Water (OiEau) (France), Organisation for Economic Co-operation and Development (OECD), United Nations Economic Commission for Europe (UNECE). The programme is principally funded by the European Union and co-funded by the Austrian Development Cooperation and the French Artois-Picardie Water Agency based on a budget of EUR 12,75 million (EUR 12 million EU contribution). The implementation period is 2021-2024.

https://eu4waterdata.eu

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List of abbreviations

ADA .... Austrian Development Agency

DG NEAR .... Directorate-General for Neighbourhood and Enlargement Negotiations of the European Commission

EC .... European Commission

EU .... European Union

EUWI+ .... European Union Water Initiative Plus

IOW/OIEau .... International Office for Water, France

OECD .... Organisation for Economic Cooperation and Development

RBD .... River Basin District

UBA .... Umweltbundesamt GmbH, Environment Agency Austria

UNECE .... United Nations Economic Commission for Europe

Country Specific Abbreviations Armenia

HMC .... Hydrometeorology and Monitoring Centre (since February 2020)

Country Specific Abbreviations Georgia

NEA .... National Environment Agency

Key messages

This first transboundary groundwater survey between Armenia and Georgia in October 2023 followed comprehensive preparation and planning which started several months in advance. It stipulated/intensified the cooperation and dialogue between the groundwater and laboratory experts of both countries. The survey covered three monitoring sites at the country border and from each groundwater site three samples were taken and analysed by three different laboratories.

The lessons learned from the survey concern two major fields:

- due to the complexity of the logistics of a transboundary survey and the number of experts involved, it is highly recommended to put more attention into the preparatory steps of the survey and to consider all eventualities.
- it is recommended to bilaterally coordinate and harmonise methodological aspects (e.g. laboratory methods, consumables etc.) as well as to intensify communication both between national sampling teams and laboratories and bilaterally between the country teams.

The lessons learned should be considered in the joint monitoring agreement between Armenia and Georgia, which is currently elaborated.

Executive Summary

In October 2023 a transboundary groundwater survey was performed in groundwater body GWB 6G-12 of the Northern River Basin District of Armenia and in the groundwater body GWB GPK0024 of the Eastern part of the Khrami-Debeda River Basin District of Georgia. In total 3 monitoring sites were sampled by three different sampling teams, from AM, GE and AT. Each water sample was then analysed by three different laboratories. Due to technical reasons a fourth sampling point could not be sampled.

The preparatory phase of the survey started in March 2023 with a physical meeting of representatives of AM and GE in Tbilisi (GE). Thereby, transboundary groundwater bodies were identified and monitoring sites were selected.

According to the monitoring results, the chemistry of the groundwater of all three monitoring sites is very similar. Except for two iron values (from the lab of Armenia), none of the measured values exceed the quality standards of the European Drinking Water Directive. The high values for iron are outliers.

The monitoring results of the three laboratories revealed significant variations for certain parameters. A clarifying online meeting with all institutions involved recommended to intensify the communication and coordination between the national sampling teams and the laboratories and to clarify all relevant specifications (e.g. sample treatment) in detail in the survey manuals.

In support of future transboundary surveys it was recommended to coordinate and harmonise analytical methods and consumables in order to minimise the risk of deviating monitoring results.

1. Introduction

1.1. Objective of the survey

The objectives of the transboundary groundwater chemical survey were:

- receiving a first impression about groundwater quality at both sides of the country border between Armenia and Georgia at the same time, which could help identifying transboundary interaction of groundwater crossing the country borders;
- intensifying the cooperation and dialogue between the groundwater experts of both countries;
- validating and strengthening the uniformity of the sampling approaches by joint sampling;
- comparing the results of three different laboratories by triple analyses of the water samples; and
- initiating a continued and harmonized cooperation between both countries based on the planned Agreement between the Ministry of Environment of the Republic of Armenia and the Ministry of Environmental Protection and Agriculture of Georgia on cooperation in the field of monitoring and exchange of information in the transboundary Khrami-Debed river basin.

1.2. Scope of the survey

Groundwater bodies and River Basin District (RBD)	Armenia: GWB 6G-12 / Northern River Basin District (RBD) Georgia: GWB GPK0024 / Eastern part of Khrami-Debed RBD
Survey location	Around Bagratashen - Sadakhlo border crossing
Number of monitoring sites	1 well in Armenia (1 additional site could not be sampled due to technical reasons) 2 springs in Georgia
Field work	3–4 October 2023
Quality elements	Field parameters, major ions, (heavy) metals

1.3. Preparatory steps

The preparatory phase started in late 2022 with a first online meeting. At a bilateral coordination workshop (29th March 2023 in Tbilisi) with representatives of Armenia and Georgia, the transboundary groundwater bodies in the Khrami-Debed RBD of Georgia and the Northern RBD in Armenia were identified and agreed upon. Thereby, the experts from both countries agreed to perform a joint transboundary groundwater survey and decided to focus at GWB GPK0024 in the Eastern part of Khrami-Debed RBD of Georgia and GWB 6G-12 in the Northern RBD of Armenia.

Following the workshop, both responsible national institutions, the Hydrometeorology and Monitoring Centre of Armenia (HMC) and the National Environmental Agency of Georgia (NEA) obtained permission from the related line ministries and prepared individual survey manuals, where the scope of the survey (e.g. monitoring sites, parameters, equipment, logistics etc.) was drafted. Based on these documents, the logistics was jointly agreed and documented in a joint survey manual. Permissions from the related border control administrations were collected and the survey took place between 2nd and 4th Oct 2023.

2. General description of the survey

2.1. Selected River Basin District and groundwater bodies

The transboundary groundwater survey focused at the GWBs GPK0024 in the Eastern part of Khrami-Debed RBD of Georgia and 6G-12 in the Northern RBD of Armenia which are next to each other (see Figure 1). At the joint meeting, both GWBs were briefly characterized (see Table 1). The overall flow direction of the groundwater follows the river from Armenia to Georgia.

Figure 1: Location of the investigated GWB GPK0024 (blue) in the Khrami-Debed RBD of Georgia and GWB 6G-12 (purple) in the Northern RBD of Armenia.

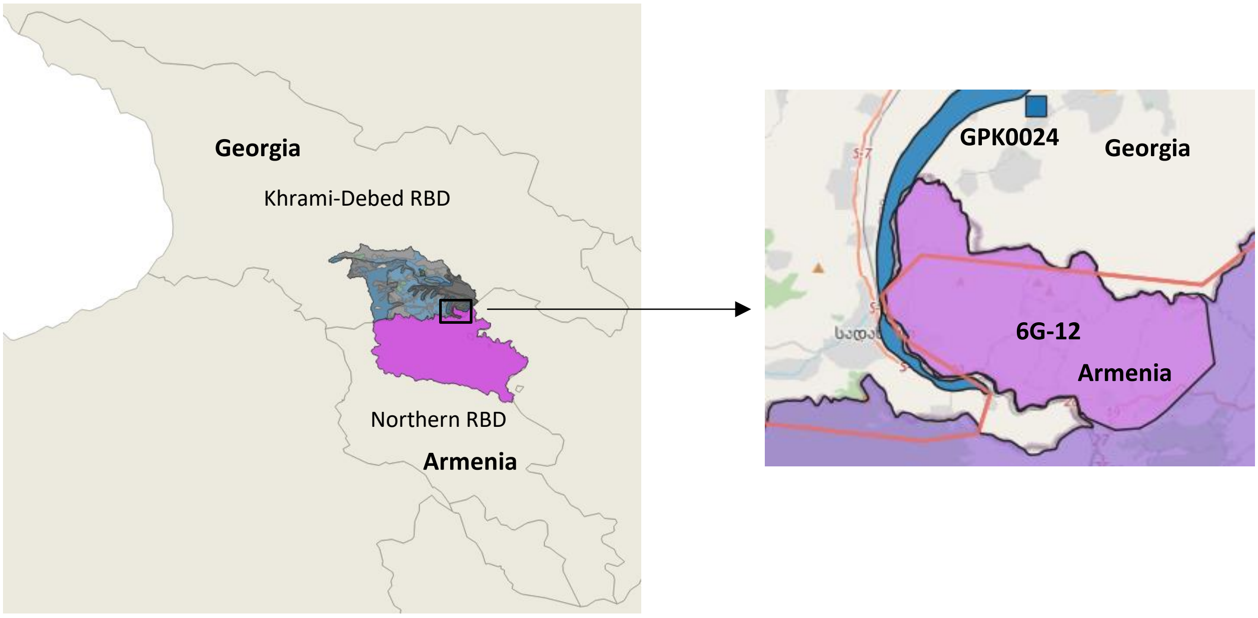


Table 1: Brief characterisation of both investigated GWBs in Georgia and Armenia.

GWB in the Northern RBD of Armenia		GWB in the Khrami-Debed RBD of Georgia	
6G-12	Depth**: 5-30m** Hydrogeology: **alluvial-proluvial** GW flow direction: **AM→GE** Quality pressures: **agriculture** Quantity pressures: **no intensive use** Challenges: **no**	**GPK0024**	Depth: **10-15m** Hydrogeology: **alluvial-proluvial** GW flow direction: **AM→GE** Quality pressure: **agriculture** Quantity pressures: **irrigation** Challenges: **no**

2.2. Selected monitoring sites

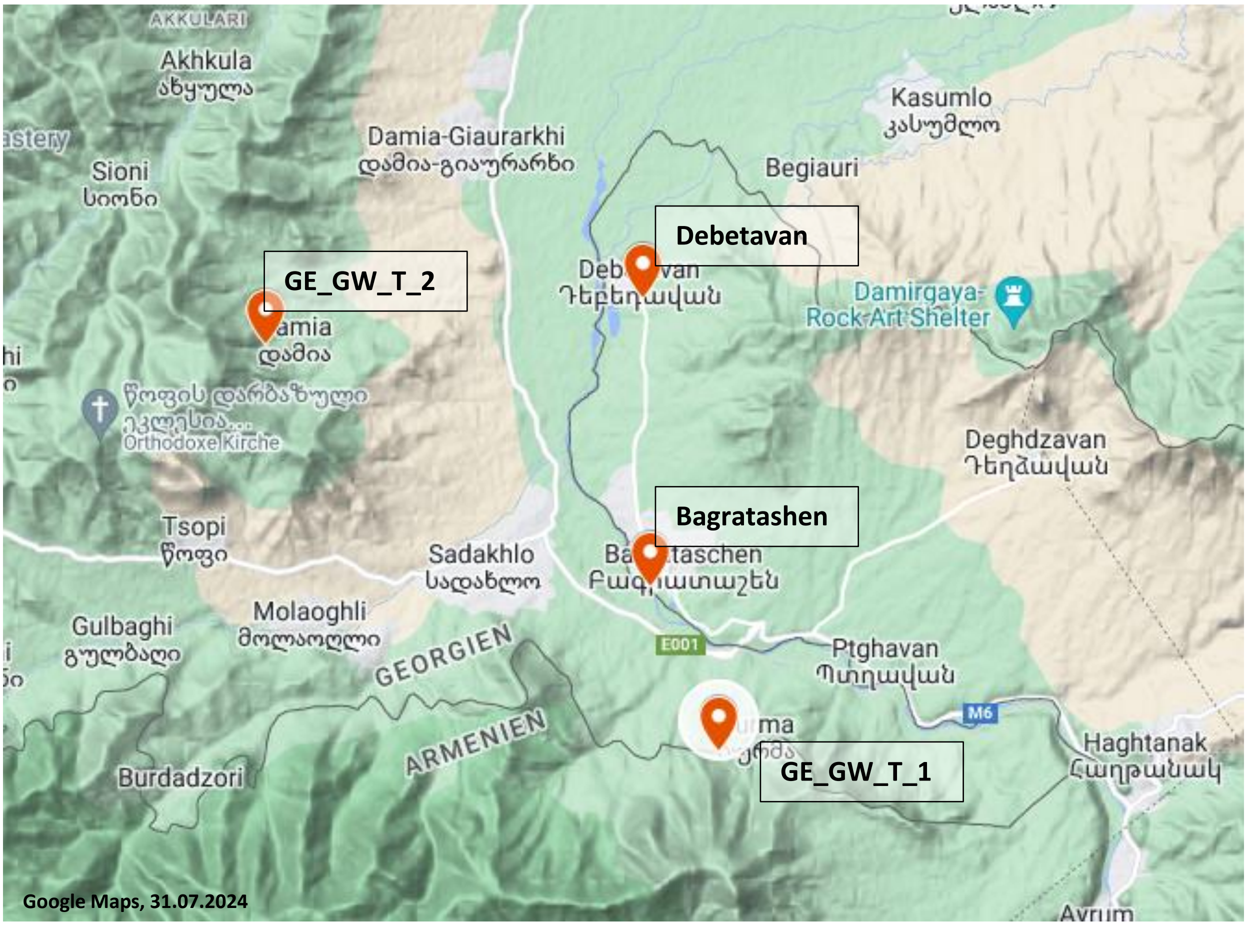
The planned sampling covered in total four already existing groundwater monitoring sites, two wells in Armenia and two springs in Georgia. Unfortunately, one site in Armenia (Debetavan) could not be sampled due to technical reasons.

Table 2: Groundwater monitoring sites subject to the transboundary groundwater survey

country	Site ID	Type of site	Location	GWB code	X coordinate	Y coordinate	Altitude m a.s.l.
AM			Bagratashen	6G-12	410 14’ 13.9”	440 49’ 01.8”	426
AM			Debetavan*	6G-12	410 16’ 37.9”	440 48’ 55.5”	429
GE	GE_GW_T_1	Spring	Village Burma	GPK0024	485936	4562672	549
GE	GE_GW_T_2	spring	Village Damia	GPK0024	478760	4568906	670

*… this site could not be sampled due to technical reasons.

Figure 2: Location of the four monitoring sites in Armenia and Georgia



2.3. Logistics and responsibilities

2.3.1. Schedule and approach

The following activities happened during the mission:

- Day 1 (Mon 2 Oct 2023): Meeting of EU Member State experts with AM experts at HMC in Yerevan for preparing the sampling equipment, calibration of the multimeter and travel to the sampling area in the Northern RBD.
- Day 2 (Tue 3 Oct 2023): Meeting with GE experts at the Bagratashen border station in Georgia and joint sampling at two GE sites. In parallel, sampling certification audit for AM experts.
- Day 3 (Wed 4 Oct 2023): Joint sampling at the sites in AM, just opposite to the GE sampling sites. In parallel, sampling certification audit for AM experts. AM experts return to Yerevan, GE and UBA experts travel to Tbilisi. Handing over of samples to the respective AM and GE laboratories. UBA experts take samples home to their laboratory; handover on Day 5 (Fr 6 Oct 2023).

At each monitoring site, each team (AM, GE and UBA) took samples according to the survey manual and by their own sampling approach, which was observed by each other.

2.3.2. Sampling team

The international team of the groundwater survey consisted of 9 national and international experts plus one driver.

Table 3: International sampling team

Name	Organisation
Armenia	
Mr. Harutyun Yeremyan	HMC
Mr. Gegham Muradyan	HMC
Mr. Gevorg Torosyan	HMC
Georgia	
Mr Merab Gaprindashvili	NEA, Department of Geology
Ms Nana Kitiashvili	NEA, Department of Geology
Mr Onise Beridze	NEA, Department of Geology
EU4Environment Water and Data	
Mr Andreas Scheidleder	UBA Environment Agency Austria
Mr Franko Humer	UBA Environment Agency Austria
Mr Vahagn Tonoyan	National representative in Armenia

2.3.3. Responsibilities in Armenia

Responsibilities	Institution, contact person, email-address
Monitoring/Sampling	**HMC, Charents 46**
Overall responsible for groundwater chemical monitoring.	Contact person: Mr Harutyun Yeremyan
Responsible for the organisation of groundwater sampling.	Contact person: Mr Harutyun Yeremyan
Groundwater sampling team	Team leader: Mr Harutyun Yeremyan Supporting persons: Mr Gegham Muradyan, Mr Gevorg Torosyan
Responsible for functional check of sampling equipment	Contact person: Mr Harutyun Yeremyan
Responsible for calibration of field measuring equipment	Contact person: Mr Harutyun Yeremyan
Laboratory	**HMC, Paruyr Sevak 5/2**
Overall contact person at the laboratory for the sampling crew	Contact person: Ms Alina Zurnachyan
Before sampling Pick-up bottles, chemicals and equipment for field measurements.	Contact person: Ms Alina Zurnachyan
After sampling Handover of filled bottles, remaining chemicals and equipment.	Contact person: Ms Alina Zurnachyan

2.3.4. Responsibilities in Georgia

Responsibilities	Institution, contact person, email-address
Monitoring/Sampling	**NEA, Department of Geology**
Overall responsible for groundwater chemical monitoring	Contact persons: Mr Merab Gaprindashvili, Ms. Nana Kitiashvili
Responsible for the organisation of groundwater sampling	Contact persons: Mr Merab Gaprindashvili, Ms. Nana Kitiashvili
Groundwater sampling team	Team leader: Mr Merab Gaprindashvili Supporting persons: Ms Nana Kitiashvili, Mr. Onise Beridze
Responsible for functional check of sampling equipment	Contact person: Ms Nana Kitiashvili
Responsible for calibration of field measuring equipment	Institution: National Environmental Agency, The Atmospheric Air, Water and Soil Analyses Laboratory Contact person: Mr Gela Sandodze
Laboratory	**NEA, The Atmospheric Air, Water and Soil Analyses Laboratory**
Overall contact person at the laboratory for the sampling crew	Contact person: Ms Lia Aptsiauri
Before sampling Pick-up bottles, chemicals and equipment for field measurements.	Contact person: Ms Lia Aptsiauri
After sampling Handover of filled bottles, remaining chemicals and equipment.	Contact person: Ms Lia Aptsiauri

2.4. Monitored quality elements

2.4.1. Parameters for field measurement

Field measurements	Unit	Measurement device AM	Measurement device GE
Depth to groundwater table	m	Solinst Model 107, ≤100 m	Solinst Model 101
Water discharge	l/s		
Water temperature	°C	YSI Pro DSS	WTW Multi 3630 IDS
Electrical conductivity	µS/cm	YSI Pro DSS	WTW Multi 3630 IDS
Dissolved oxygen	mg/l	YSI Pro DSS	WTW Multi 3630 IDS
pH value		YSI Pro DSS	WTW Multi 3630 IDS
Odour			
Colour			
Taste			
Turbidity			

2.4.2. Parameters for laboratory analyses

Parameter/Indicator	Unit	Sample treatment / Conservation
Major ions		
Calcium Ca	mg/l	No sample treatment and no conservation
Magnesium Mg	mg/l	
Sodium Na	mg/l	
Potassium K	mg/l	
Chloride Cl	mg/l	
Nitrate NO3	mg/l	
Sulphate SO4	mg/l	
Hydrogen carbonate HCO3	mg/l	
Nitrite NO2	mg/l	
Ammonia NH4	mg/l	
Total mineralisation	mg/l	
Total hardness	mg/l	
Metals		
Iron Fe	mg/l	AM, GE, UBA: unfiltered*, acidification with HNO_3 UBA: filtration with 45µm and acidification with HNO_3
Manganese Mn	mg/l	
Aluminium Al	mg/l	
Arsenic As	mg/l	
Lead Pb	mg/l	
Cadmium Cd	mg/l	
Chromium Cr	mg/l	
Copper Cu	mg/l	
Nickel Ni	mg/l	
Zinc Zn	mg/l	

***…** AM: 2 L of water will be taken from the source without any treatment.

3. Sampling

3.1. Sampling and field measurements

The water sampling for physico-chemical analyses was conducted following the requirements of ISO 5667-3:2018 and the General Manual for Chemical Freshwater Sampling (EUWI+, ENI/2016/372-403).

The sampling teams of Armenia, Georgia and UBA performed their procedures of field measurements, sample treatment and sampling individually and in parallel.

Field measurements were done directly at the source or in a bucket in the flowing water. After that, the bottles were filled according to the requirements defined in the survey manual.

Nationally used sampling protocols were completed.

The samples were treated as follows:

- AM, GE and UBA: no stabilization of samples for major ion analyses.
- AM, GE and UBA: no filtration of samples for metal analyses. Stabilization with HNO_3. UBA team used the acid from Armenia.
- UBA: filtration and stabilization of samples for metal analyses. Furthermore, a blank sample was taken with the stabilization acid only.

Table 4: Used bottles for the samples

Item	Size (ml, litre)	Labelling of bottle
Armenia		
Plastic bottles – PE	0.5 L	Ions
Plastic bottles – PP, Tube 30ml, 84x30mm	40 ml	Metals
Georgia		
Plastic bottles – PET	1 L	Ions
Plastic bottles	40 ml	Metals
UBA		
Plastic bottles – PET	1 L	Ions
Plastic bottles – PP	2 x 50 ml	Ions
Plastic bottles – PP	2 x 50 ml	Metals filtered
Plastic bottles – PP	2 x 50 ml	Metals unfiltered

All bottles were put into cooling boxes immediately after the sampling. The preservation, handling, transport and storage of all water samples were followed the procedure outlined in ISO 5667-3:2018 laboratory standard operating procedure.

On October 3, both samples taken in Georgia were transported to the laboratory (NEA) on the same day by specially allocated transport. 1 sample taken in Armenia was handed over to NEA's laboratory on October 4. The other water samples were transported to the laboratory of HMC after the 2^{nd} day of the survey. The samples of UBA were transported to the UBA laboratory at the end of the mission on 6 Oct 2023.

3.2. Problems observed

Four GW monitoring sites have been visited and three of them were sampled - two GE sites and one AM site. The sampling at the two springs in GE was straight forward. The sampling at the two proposed AM sites was a bit difficult.

At the GW well 'Debetavan', sampling was impossible due to technical problems with the pump. The extraction of sufficient GW by the bailer to fill three sets of sampling bottles (AM, GE UBA) was overall unrealistic.

The GW well 'Bagratashen' was very closely located at the bench of the border river. Unfortunately, the rules for entering the close border area changed recently, hence it was impossible for UBA and GE experts to approach the last 50 m to the sampling site. One AM expert was allowed to approach the site, escorted by the border police. He abstracted GW and carried it in buckets to the other experts, who took field measurements and filled sampling bottles from the water in the buckets. GE and UBA experts were not able to see, how the groundwater was abstracted and if QA requirements were fully respected.

4. Survey results

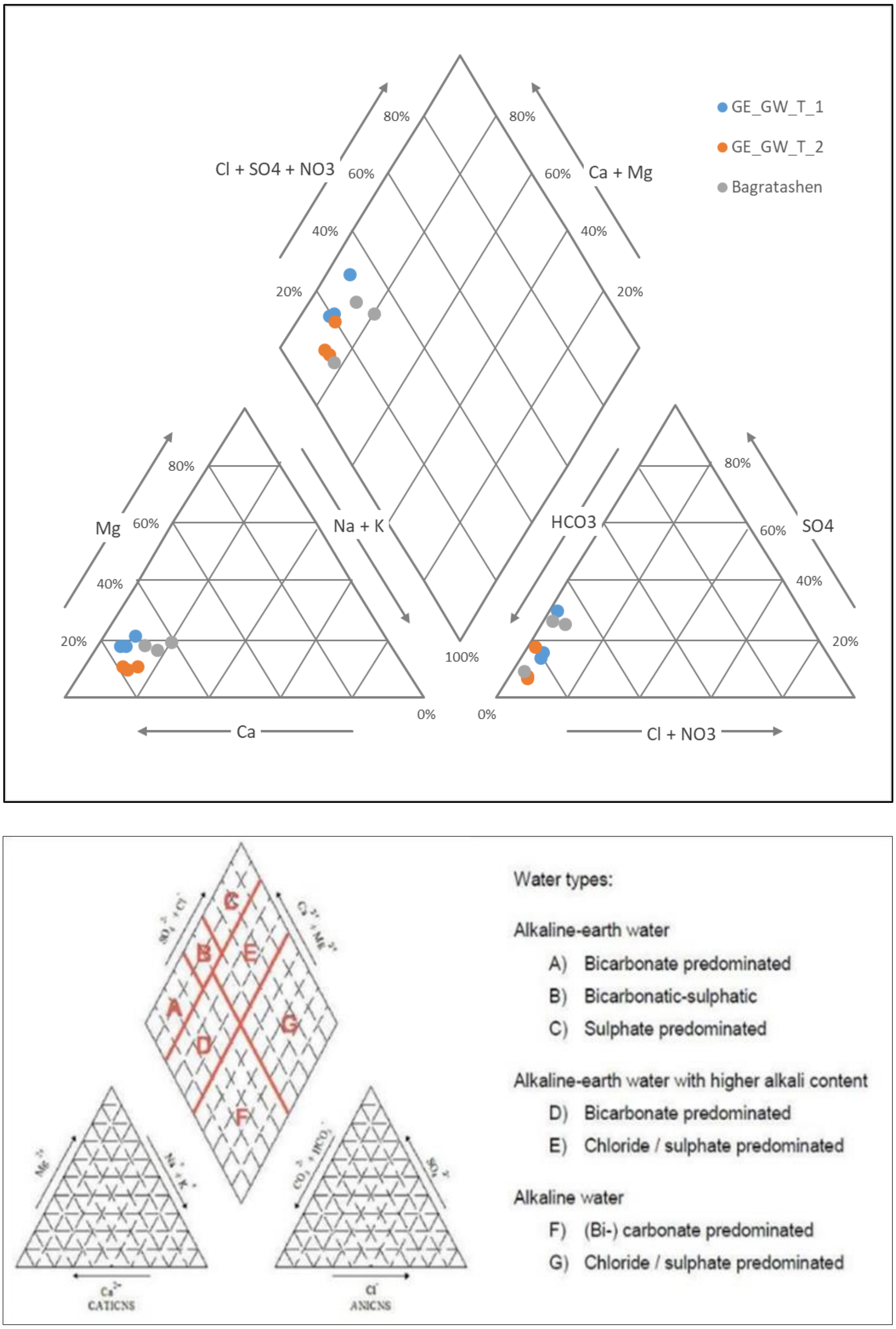
At the joint transboundary groundwater survey between AM and GE in October 2023 three groundwater samples were taken by AM, GE and UBA experts. All samples were analysed by the three corresponding laboratories of HMC (AM), NEA (GE) and UBA (AT).

The laboratory analyses has revealed that all water samples can be classified as "HCO_3^- predominated" on the basis of the Piper-Furtak diagram (Figure 3). Additionally, the samples can be assigned to the Ca-HCO_3^- subclass. Although all samples belong to the same water type, the total mineralization varies between the samples taken at GE_GW_T_1 (Burma 1) to the samples from GE_GW_T_2 (Damia 2) and Bagratashen 3. The different mineralization correlates well with the measured electrical conductivity in the field. Furthermore the nitrate and chloride concentration is different. The highest mean nitrate concentration of 14.63 mg/l (mean of the three laboratories) was measured in the sample from GE_GW_T_1. In the other two samples the nitrate concentration is below 10 mg/l. The mean chloride concentration is >5 mg/l in the samples from GE_GW_T_1 and Bagratashen and <5mg/l in the sample from GE_GW_T_2. The analysis of the filtrated samples has revealed that the concentration of arsenic, chromium, manganese and iron is highest in the samples from Bagratashen, which correlates with the lowest oxygen concentration measured in the field.

The variations of the laboratory results for selected parameters can be seen in Schöller diagrams (Figure 5-7). Please be aware of the logarithmic scale. Figure 4 compares the mean laboratory results of the three monitoring sites.

A comparison of the individual results from each laboratory revealed that the results especially for the parameters iron (unfiltrated), sulphate and hydrogencarbonate differ by up to a factor of 225 between the different laboratories (Tables 5–7). As a consequence the iron concentrations of the samples analysed by Armenia exceed the drinking water standard of the EU Drinking Water directive of 200 mg/l at the samples taken at site GE_GW_T_1 (Burma 1) and GE_GW_T_2 (Damia 2).

Figure 3: Piper-Furtak diagram



Source: https://www.researchgate.net/figure/Classification-of-hydrochemical-water-types-according-to-Furtak-and-Langguth-1967_fig1_325261043

Figure 4: Schöller diagram of laboratory mean values

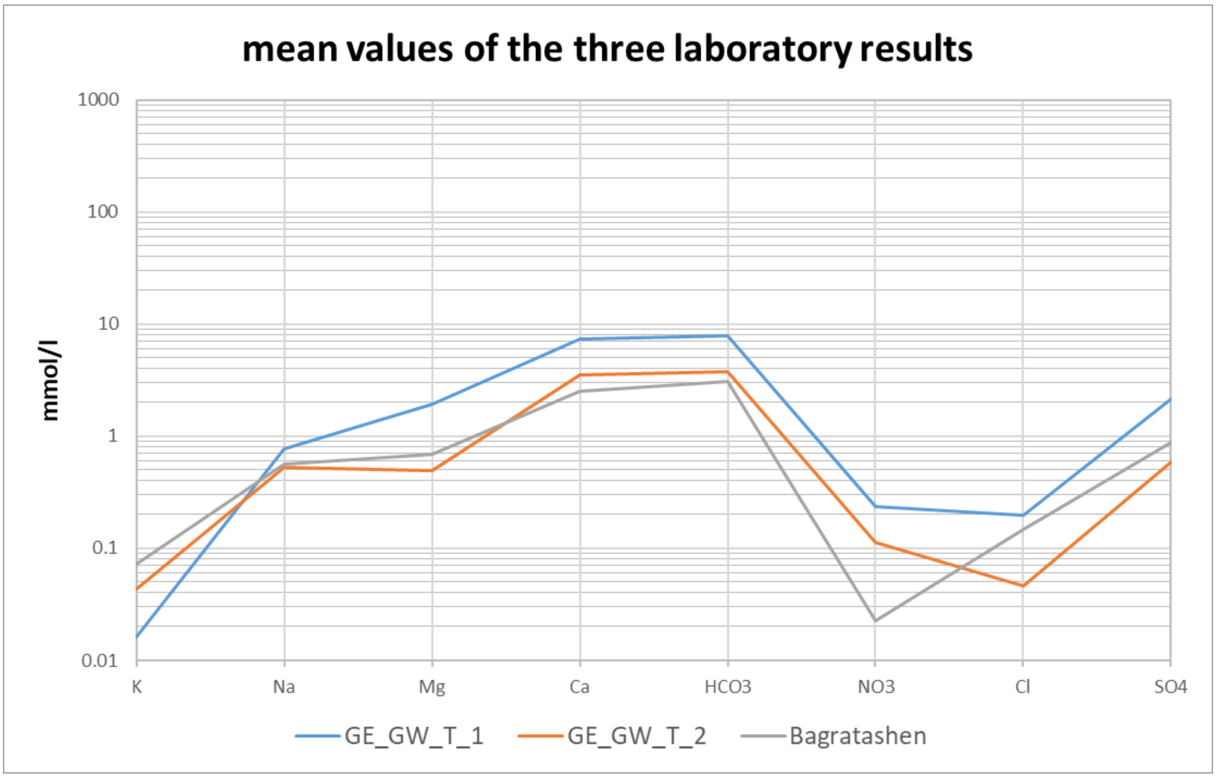


Figure 5: Schöller diagram of results from GE_GW_T_1

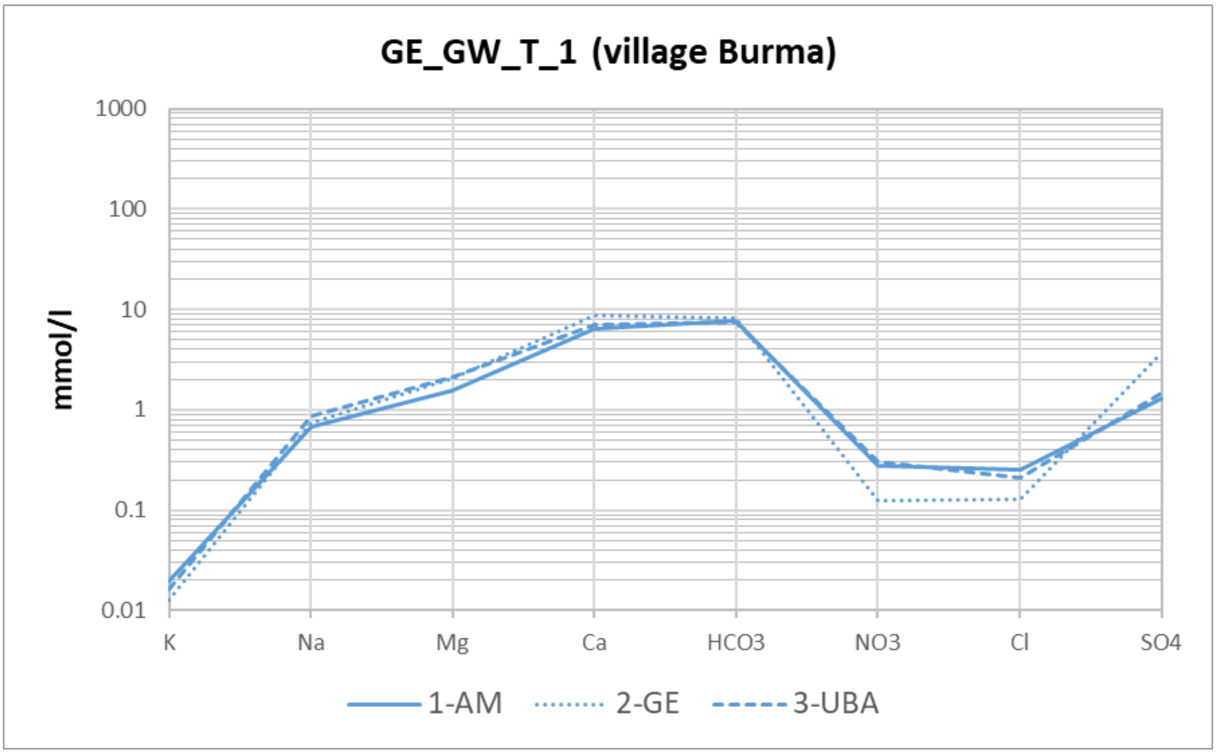


Figure 6: Schöller diagram of results from GE_GW_T_2

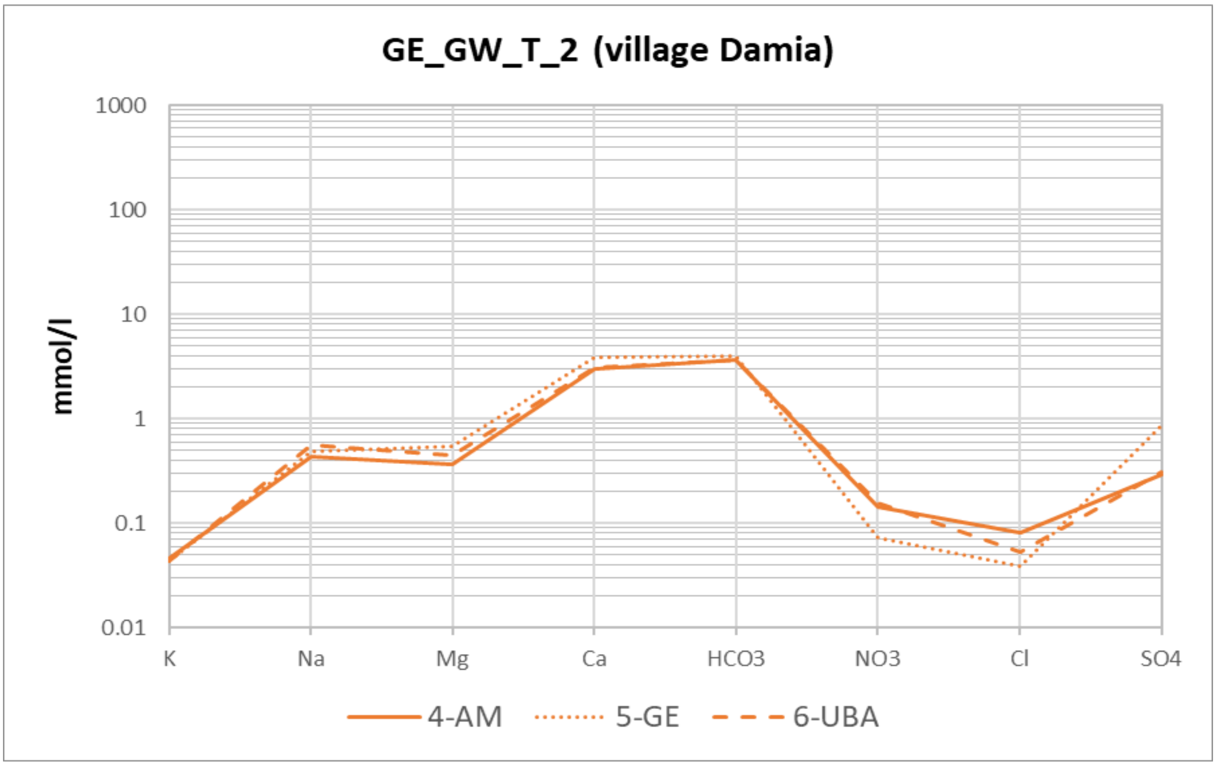
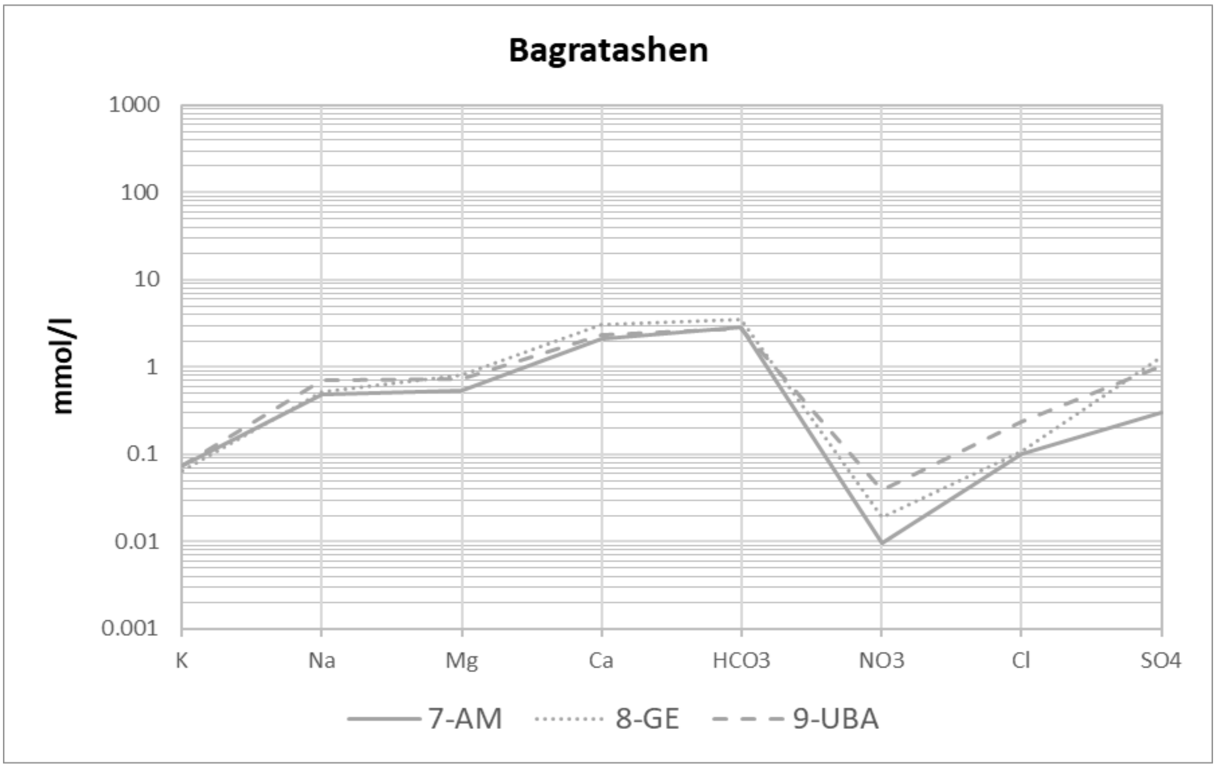


Figure 7: Schöller diagram of results from Bagratashen well



The results of the laboratory analyses are displayed in the following three tables. In addition to the results also the drinking water standards of the EU Drinking Water Directive (2020/2184) are given in column "EU DW". Yellow colour means that the measured value exceeds the respective drinking water standard.

Table 5: Laboratory results for sampling site GE_GW_T_1 (village Burma)

Parameter		Unit	EU DW	AM	GE	UBA	UBA
Date / Time	3.10.2023 / 11:00 local time (9:00 CET)						
Field measurements							
Spring discharge		l/s	5L/80 sec = 0.065 l/s				
Temperature		°C			18.5	18.4	
pH-value			≥ 6,5 ≤ 9,5		7.58	7.56	
Turbidity		NTU			0.17		
Dissolved oxygen		mg/l	5		8.23	8.23	
Dissolved oxygen		%			93.3	93.9	
Electrical conductivity		µS/cm	2500	846	908	911	
Colour				5			
Smell				0			
Laboratory measurements							**Test strips**
pH-value			≥ 6,5 ≤ 9,5	7.79			
Transparency				31			
Suspended particles				2.6			
TDS		mg/l		550	924	590	
Total hardness				8.063 mgeq/l	10.9 mg.eqv/l	460 mg/l	
Total hardness		°dH		45,3	61,2	25,8	>21
Chloride	Cl	mg/l	250	8.83	4.54	7.40	
Hydrogencarbonate	HCO3	mg/l		463.8	501.4	460.0	
Ammonium	NH4	mg/l	0.5	0.14	0.32	0.03	0
Nitrite	NO2	mg/l	0.5	0.01	0.14	< 0.010	0
Nitrate	NO3	mg/l	50	17.17	7.73	19.00	88.6
Sulphate	SO4	mg/l	250	61.75	174.97	71.00	
Calcium	Ca	mg/l		129.78	177.15	140.00	
Sodium	Na	mg/l	200	15.52	17.33	20.00	
Potassium	K	mg/l		0.77	0.50	0.64	
Magnesium	Mg	mg/l		18.89	25.08	26.00	
			unfiltrated				**filtrated**
Aluminium	Al	µg/l	200	< 5.0	1.2	3.8	3.1
Arsenic	As	µg/l	10	0.4	6.9	0.6	0.5
Cadmium	Cd	µg/l	5	< 0.1	0.2	0.01	0.01
Chromium	Cr	µg/l	25	1.0	3.8	< 0.1	< 0.1
Copper	Cu	µg/l	2	0.9	0.7	1.1	0.7
Iron	Fe	µg/l	200	565.9	15.6	2.5	0.9
Manganese	Mn	µg/l	50	0.1	0.9	0.3	0.2
Nickel	Ni	µg/l	20	3.0	1.4	0.3	0.3
Lead	Pb	µg/l	5	< 0.1	2.2	0.05	0.01
Zinc	Zn	µg/l		0.5	4.5	0.5	0.3

Table 6: Laboratory results for sampling site GE_GW_T_2 (village Damia)

Parameter		Unit	EU DW	AM	GE	UBA	UBA
Date / Time	3.10.2023 / 12:00 local time (10:00 CET)						
Field measurements							
Spring discharge		l/s	5L/130 sec = 0.038 l/s				
Temperature		°C			17.8	17.8	
pH-value			≥ 6,5 ≤ 9,5		7.32	7.30	
Turbidity		NTU			0.16		
Dissolved oxygen		mg/l	5		8.01	7.98	
Dissolved oxygen		%			90		
Electrical conductivity		µS/cm	2500	413	407	407	
Colour				5			
Smell				0			
Laboratory measurements							**Test strips**
pH-value			≥ 6,5 ≤ 9,5	7.61			
Transparency				31			
Suspended particles				1.5			
TDS		mg/l		413	398	250	
Total hardness				3.363 mgeq/l	4.44 mg eqv/l	180 mg/l	
Total hardness		°dH		18.9	24.9	10.1	>14
Chloride	Cl	mg/l	250	2.87	1.39	1.90	
Hydrogencarbonate	HCO3	mg/l		225.8	241.6	220.0	
Ammonium	NH4	mg/l	0.5	0.02	0.27	0.02	0-0.32
Nitrite	NO2	mg/l	0.5	0.01	0.13	< 0.01	0
Nitrate	NO3	mg/l	50	8.98	4.46	9.70	12.15
Sulphate	SO4	mg/l	250	13.83	41.56	15.00	
Calcium	Ca	mg/l		59.77	78.20	62.00	
Sodium	Na	mg/l	200	9.98	11.08	13.00	
Potassium	K	mg/l		1.82	1.68	1.70	
Magnesium	Mg	mg/l		4.50	6.57	5.50	
			unfiltrated				**filtrated**
Aluminium	Al	µg/l	200	< 5.0	1.0	2.8	2.1
Arsenic	As	µg/l	10	0.5	1.5	0.6	0.5
Cadmium	Cd	µg/l	5	< 0.1	0.2	< 0.005	< 0.005
Chromium	Cr	µg/l	25	0.2	3.1	< 0.1	< 0.1
Copper	Cu	µg/l	2	0.4	0.2	1.0	0.5
Iron	Fe	µg/l	200	262.0	13.3	1.5	0.7
Manganese	Mn	µg/l	50	0.2	0.9	0.4	0.2
Nickel	Ni	µg/l	20	1.3	0.7	0.2	0.1
Lead	Pb	µg/l	5	< 0.1	4.3	0.1	< 0.005
Zinc	Zn	µg/l		< 0.1	4.4	0.5	n.n.

Table 7: Laboratory results for sampling site AM Bagratashen

Parameter		Unit	EU DW	AM	GE	UBA	UBA
Date / Time	4.10.2023 / 12:45 local time (10:45 CET)						
Field measurements							
Spring discharge		l/s	Pumping well				
Temperature		°C			18.0	18.0	
pH-value			≥ 6,5 ≤ 9,5		7.03	7.03	
Turbidity		NTU			0.89		
Dissolved oxygen		mg/l	5		2.26	2.26	
Dissolved oxygen		%			23.6	23.6	
Electrical conductivity		µS/cm	2500	400	437	437	
Colour				10			
Smell				5			
Laboratory measurements							**Test strips**
pH-value			≥ 6,5 ≤ 9,5	7.77			
Transparency				31			
Suspended particles				1.5			
TDS		mg/l		260	429	250	
Total hardness				2.682 mgeq/l	4.88 mg eqv/l	150 mg/l	
Total hardness		°dH		15.1	27.4	8.43	>7
Chloride	Cl	mg/l	250	3.64	3.85	8.30	
Hydrogencarbonate	HCO3	mg/l		177.0	213.5	170.0	
Ammonium	NH4	mg/l	0.5	0.04	0.27	0.02	0
Nitrite	NO2	mg/l	0.5	0.01	0.12	< 0.01	0-0.49
Nitrate	NO3	mg/l	50	0.60	1.17	2.40	8.86-22.15
Sulphate	SO4	mg/l	250	14.62	62.90	50.00	
Calcium	Ca	mg/l		42.90	62.16	47.00	
Sodium	Na	mg/l	200	11.15	12.12	16.00	
Potassium	K	mg/l		2.93	2.55	2.90	
Magnesium	Mg	mg/l		6.44	9.84	8.90	
			unfiltrated				**filtrated**
Aluminium	Al	µg/l	200	10.0	1.4	4.0	1.9
Arsenic	As	µg/l	10	5.6	5.5	6.7	5.9
Cadmium	Cd	µg/l	5	0.2	0.1	0.1	0.1
Chromium	Cr	µg/l	25	0.5	5.3	< 0.1	< 0.1
Copper	Cu	µg/l	2	2.5	3.5	4.3	3.5
Iron	Fe	µg/l	200	185.0	55.1	110.0	3.3
Manganese	Mn	µg/l	50	3.2	3.9	5.6	4.5
Nickel	Ni	µg/l	20	1.1	1.5	0.3	0.2
Lead	Pb	µg/l	5	< 0.1	2.2	0.1	0.01
Zinc	Zn	µg/l		2.9	2.0	3.1	2.4

5. Lessons learned

5.1. Survey preparation

Planning of a joint transboundary survey might need more careful preparation than a national survey because specific time restricted permissions might need to be applied for and usually more experts participate, which is a significant cost factor. A joint collection of samples is a very special activity which needs national and bilateral agreements well in advance. Hence, all the preparatory efforts on both sides should not be endangered or detracted by 'simple' reasons, as a repetition of such a survey is usually very difficult or even impossible.

Recommendations

- Check with the owner of the site and with relevant (border) administrations (few days) before the survey, whether the sites are accessible as planned.
- Already identify and nominate 1–2 replacement sites which could be sampled if there are any troubles at any planned site.
- Visit the monitoring points, which are not permanently used or not monitored recently, in advance of the survey and check both accessibility and presence of water. In doing so, at wells that were not used for a long time, it is recommended to intensively purge until the pumped water is clean and the field measurements are stable.
- Check the depth of the groundwater level in order to select an appropriate pump that can handle such depths. Consider that the maximum depth given for a pump is not achievable by older pumps and/or with insufficient capacity of the battery.
- When checking the equipment for the survey, it is highly recommended to check the functionality of the pump with water.
- Bring sufficient spare batteries of the correct size for the field equipment and bring the manuals in printed form (internet service might not be available everywhere).

5.2. Comparability of results

The comparison of monitoring results showed partly significant differences between the three involved laboratories (see Figure 5-7). All GW experts sampled in the same quality assured way and all laboratories follow quality control.

A joint online meeting was held with representatives of the groundwater sampling teams, of the analysing laboratories from Armenia, Georgia and UBA and of the EU4Environment-Water and Data project team to discuss the different reasons for the deviation of results and how to improve for the future.

HMC mentioned that the limits of quantification (LOQ) of metals are higher than at the other laboratories. NEA raised that the values were checked twice but it should be considered that the time between sampling and analyses is different for the three labs.

Recommendations

- This open communication and cooperation between administrations and experts should continue on a regularly basis.
- It is recommended to review and strengthen the communication and cooperation processes between the laboratories and the sampling teams. The laboratory teams need to describe exactly the sampling, treatment and preservation methods of the samples (according to ISO standards), that have to be followed by the sampling team.
- The joint (sampling team and laboratory) preparation of a survey manual for each survey campaign would be an excellent basis in clarifying and documenting all these aspects from the preparatory phase to the hand-over at the end of a survey.
- Both, the groundwater sampling teams and the laboratories follow their quality assurance procedures. Nevertheless, as a first step, it was recommended that the laboratories check the cleaning processes of bottles and the quality of the stabilisation chemicals.
- For future transboundary groundwater surveys, it is recommended to first coordinate and harmonise analytical methods, equipment and/or to use the same reagents for treatment and analyses. It could also minimize errors if the laboratory analyses will all be performed at the same day.
- To simplify data transfer and avoid errors by additional handling of data, it is recommended to jointly elaborate data transfer templates. Furthermore, joint multilingual sampling protocols would allow mutual exchange which contributes to quality assurance. Ideally also laboratory reports should be readable for both parties.
- The joint monitoring agreement between Armenia and Georgia, which is the legal basis for joint cooperation, should be updated by these conclusions and recommendations. It was also proposed to circulate the draft agreement and organize a joint meeting of decision makers and experts and to add the groundwater part to a technical document specifying the technical details as currently discussed.

Overall, this transboundary groundwater survey was very valuable and provides significant lessons learned.

Funded by the European Union

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