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

SURFACE WATER SURVEY IN THE NORTHERN WBMA 2023 ARMENIA

Contract-No: 20940-C1/AM-HMC-2023/5

Funded by the European Union

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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 action is co-funded by the European Union, 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

BQE ..... Biological Quality Elements

COD..... Chemical Oxygen Gemand

EC..... European Commission

ESCS ..... Ecological Status Classification Systems

EU ..... European Union

EU4EnvWD..... EU4Environment in Eastern Partner Countries: Water Resources and Environmental Data

EUWI+..... European Union Water Initiative Plus

HPP ..... Hydropower Plant

RBD ..... River Basin District

SW..... Surface water

UBA..... Umweltbundesamt GmbH, Environment Agency Austria

WFD ..... Water Framework Directive

Country Specific Abbreviations Armenia

HMC..... Hydrogeological Monitoring Centre (since February 2020)

SNCO..... State non-commercial organization

WBMA ..... Water Basin Management Area

Executive Summary

Within the Program “EU4Environment in the Eastern Partnership: Water Resources and Environmental Data – implementation by EU Member State Agencies” (Agreement number - 20940-C1/AM-HMC-2023/5) an ecological survey was carried out at 25 sampling sites in Northern water basin management area (WBMA) in the Republic of Armenia. The survey encompassed water and hydrobiological sampling, chemical and biological analyses and the hydro-morphological description of the sampling sites.

Based on the biological data, 12 sites were classified as “High”, for as “Good”, one as “Moderate”, three as “Poor” and four as “Bad”. 1 Site could be classified only based on physico-chemical data.

In several cases, the biological quality element indicated a better status class than when using the physico-chemical water quality parameters. This indicates a need for evaluating and possibly revising the class boundaries for the chemical parameters.

1. Introduction and scope

The objective of the survey in summer 2023 was to form a sound methodological basis for future monitoring programs as essential part of river basin management planning.

The scope was to:

- Provide data for the evaluation of the water body delineation;
- Provide data for the evaluation of the monitoring design in preparation of further surveys;
- Provide data for the pressure-impact assessment in order to evaluate existing assessment methods or develop new ones;
- Create a database for the risk, status and trend assessment

2. General description of the survey

2.1. Sampling sites

The sampling was conducted in 25 sites, comprising 20 sites in the Debed and 5 sites in the Aghstev river basins of the Northern WBMA. The list and descriptions of the sampling sites are provided in Table 1 and illustrated in Figure 1. For detailed information on altitude, catchment area, geology, and typology, please refer to Annex 1 and 3.

Table 1. List of sampling sites in Northern WBMA

River Basin	River name	Site location	Site No.	Longitude	Latitude
Debed	Chichkhan	Shirakamut	CS	40.916102	44.116103
	Tandzut	Antarashen	TA	40.738948	44.618455
	Tandzut	Vanadzor	TV	40.77615	44.557665
	Lernajur	Lernapat	LL	40.802836	44.37816
	Dzoraget	Katnarat	363	41.05024	44.175459
	Dzoraget	Novoselcovo, down to	DN	41.048067	44.304833
	Katnaghbyur	Armanis (river mouth)	366	41.01126	44.35633
	Urut	Bovadzor	UB	41.039527	44.395222
	Dzoraget	Dzoraget (river mouth)	10	40.957834	44.630417
	Martsiget	Atan	MA	40.942285	44.842534
	Alareqs	Depet	361	40.910126	44.658925
	Lalvar	Alaverdi (river mouth)	368	41.099452	44.657949
	Shereq	Jivanq	SJ	41.070515	44.710688
	Akhtala	Akhtala (river mouth)	14	41.149334	44.781755
	Nahatak	Mets Ayrum (river mouth)	373	41.165297	44.837384

River Basin	River name	Site location	Site No.	Longitude	Latitude
	Debed	Qarkop	370	41.178305	44.860401
	Shnogh	Teghut	ST	41.099	44.891013
	Shnogh	Shnogh (river mouth)	343	41.14376	44.832789
	Debed	Bagratashen (border)	7	41.218251	44.869809
	Sedvi	Alaverdi	SA	41.082651	44.609453
Aghstev	Aghstev	Lermontovo	Ag	40.770302	44.621012
	Bareber	Barepat	BB	40.666628	45.115473
	Paytajur	Gandzaqar	PG	40.829797	45.154531
	Sarnajur	Getahovit	SG	40.90519	45.115095
	Aghstev	Ijevan (down to)	18	40.949925	45.165854

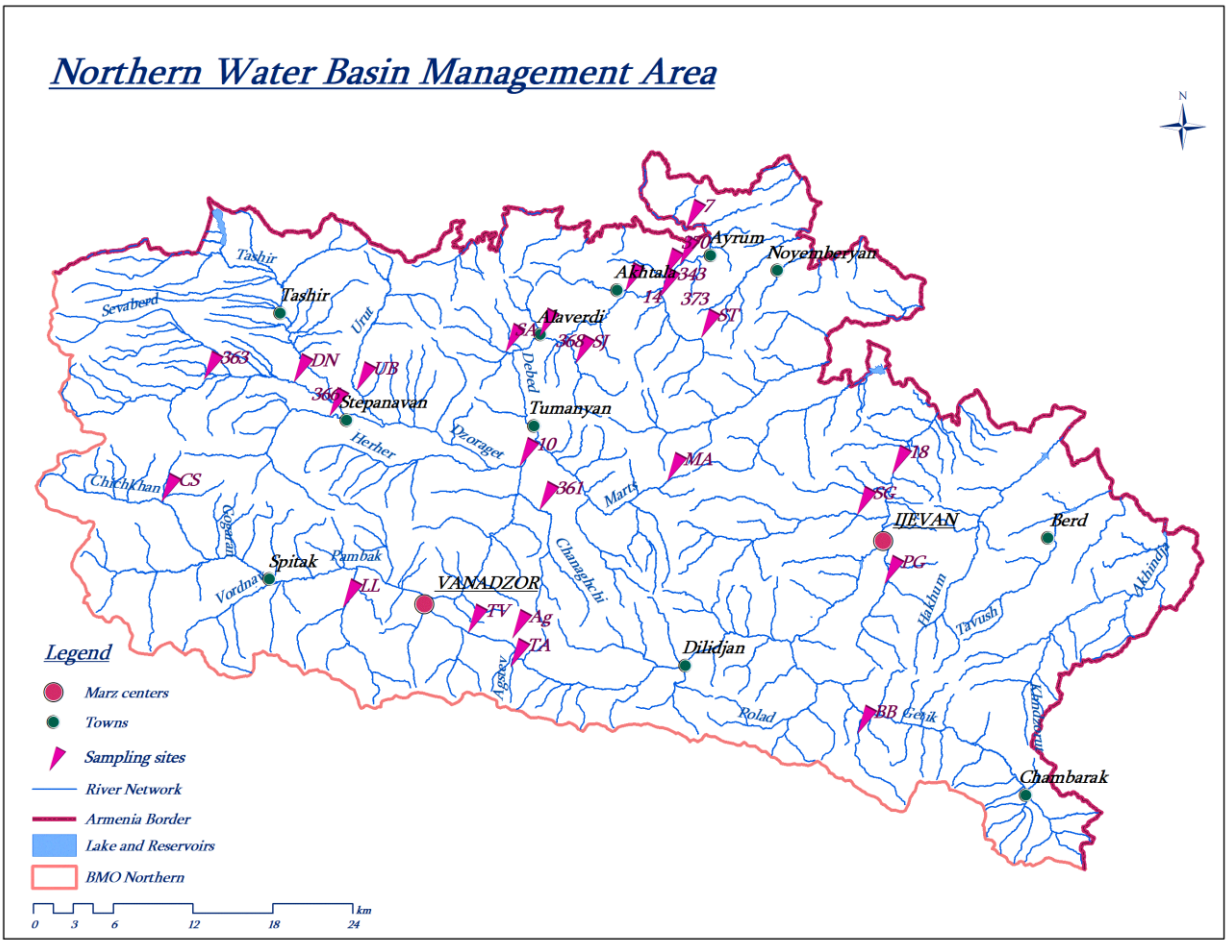

Figure 1. Map of Water Sampling Sites in the Northern WBMA

2.2. Sampling period

Sampling took place during two periods: from June 19 to 27 and from July 17 to 21, 2023. In June, during fieldwork, the inner reaches of the Debed River basin experienced severe flooding due to heavy mudslides. Consequently, sampling activities at affected sites were postponed to July. It was impossible to carry out hydrobiological sampling at the Armenia-Georgia border sampling site - 7 due to the tightening of the border control service.

The scheduling of field survey transportation was coordinated with the experts responsible for the sampling. The detailed information on meteorological and hydrological conditions during the sampling periods is presented in Table 2.

Table 2 Meteorological and hydrological conditions

River Basin	*Date*	*Site No.*	*Meteorology*	*Hydrology*
Debed	*19.06.2023*	*CS*	*Light conditions: Sunny;* *Precipitation: Dry;* *Air temperature: Warm;* *Wind: Not available*	*River type: middle* *Stream order: first* *Turbidity of water: no turbidity*
Debed	*26.06.2023*	*TA*	*Light conditions: Sunny;* *Precipitation: Dry;* *Air temperature: Mild;* *Wind: Not available*	*River type: small* *Stream order: first* *Turbidity of water: no turbidity*
Debed	*26.06.2023*	*TV*	*Light conditions: Sunny;* *Precipitation: Dry;* *Air temperature: Warm;* *Wind: Not available*	*River type: small* *Stream order: first* *Turbidity of water: no turbidity*
Debed	*19.06.2023*	*LL*	*Light conditions: Sunny;* *Precipitation: Dry;* *Air temperature: Warm;* *Wind: Not available*	*River type: small* *Stream order: first* *Turbidity of water: no turbidity*
Debed	*20.06.2023*	*363*	*Light conditions: Partly cloudy;* *Precipitation: Dry;* *Air temperature: Mild;* *Wind: Not available*	*River type: small* *Stream order: first* *Turbidity of water: no turbidity*
Debed	*20.06.2023*	*DN*	*Light conditions: Cloudy;* *Precipitation: Dry;* *Air temperature: Mild;* *Wind: Not available*	*River type: middle* *Stream order: first* *Turbidity of water: no turbidity*
Debed	*20.06.2023*	*366*	*Light conditions: Cloudy;* *Precipitation: Dry;* *Air temperature: Warm;* *Wind: Not available*	River type: middle *Stream order: second* *Turbidity of water: Slightly turbid*

River Basin	*Date*	*Site No.*	*Meteorology*	*Hydrology*
Debed	*20.06.2023*	*UB*	*Light conditions: Cloudy; Precipitation: Raining; Air temperature: Mild; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*
Debed	*17.07.2023*	*10*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: middle Stream order: second Turbidity of water: no turbidity*
Debed	*20.07.2023*	*MA*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*
Debed	*17.07.2023*	*361*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*
Debed	*21.06.2023*	*368*	*Light conditions: Cloudy; Precipitation: Dry; Air temperature: Mild; Wind: Not available*	*River type: small Stream order: first Turbidity of water: Moderate turbidity*
Debed	*20.07.2023*	*SJ*	*Light conditions: Cloudy; Precipitation: Dry; Air temperature: Mild; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*
Debed	*22.06.2023*	*14*	*Light conditions: Cloudy; Precipitation: Dry; Air temperature: Mild; Wind: Calm*	*River type: small Stream order: first Turbidity of water: Turbid*
Debed	*21.07.2023*	*373*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: first Turbidity of water: Moderate turbidity*
Debed	*21.07.2023*	*370*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: large Stream order: second Turbidity of water: no turbidity*
Debed	*22.06.2023*	*ST*	*Light conditions: Cloudy; Precipitation: Drizzle; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*
Debed	*22.06.2023*	*343*	*Light conditions: Cloudy; Precipitation: Dry; Air temperature: Mild; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*

River Basin	*Date*	*Site No.*	*Meteorology*	*Hydrology*
Debed	*22.06.2023*	*7*	*Light conditions: Cloudy; Precipitation: Raining; Air temperature: Warm; Wind: Not available*	*River type: large Stream order: second Turbidity of water: Moderate turbidity*
Debed	*20.07.2023*	*SA*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Hot; Wind: Calm;*	*River type: small Stream order: first Turbidity of water: no turbidity*
Aghstev	*26.06.2023*	*Ag*	*Light conditions: Partly cloudy; Precipitation: Dry; Air temperature: Mild; Wind: Calm*	*River type: small Stream order: first Turbidity of water: no turbidity*
Aghstev	*26.06.2023*	*BB*	*Light conditions: Cloudy; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*
Aghstev	*27.06.2023*	*PG*	*Light conditions: Cloudy; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*
Aghstev	*27.06.2023*	*SG*	*Light conditions: Partly cloudy; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*
Aghstev	*27.06.2023*	*18*	*Light conditions: Cloudy; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: large Stream order: second Turbidity of water: Moderate turbidity*

2.3. Responsibilities

For the proper execution of the survey, each part has an assigned responsible person. Contact information for these responsible individuals is provided in Table 3.

Table 3. Responsible institutions and persons in preparation and during the survey.

Responsibilities	Institution, contact person, email-address
General	
Responsible for the organization of surface water sampling	Institute: Hydrometeorology and Monitoring Center SNCO Contact person: Alina Zurnachyan (Head of surface water quality monitoring service) E-Mail: alina.zurnachyan@gmail.com Vardan Karyan (Head of Soil, Sediment and Hydrobiology Service) E-Mail: VHKaryan@gmail.com

Responsibilities	Institution, contact person, email-address
Overall responsible for reporting and data delivery	Institute: Hydrometeorology and Monitoring Center SNCO Contact person: Gayane Shahnazaryan (Deputy Director), E-Mail: shahnazaryangayane@gmail.com
Field work	
Responsible for field work (biological and chemical sampling, hydro-morphological site description, hydrological measurements)	Institute: Hydrometeorology and Monitoring Center SNCO Chemical: Tigran Araqelyan, E-Mail: tigranarakelyan91@mail.ru Biological: Vardan Karyan, E-Mail: VHKaryan@gmail.com, Hayk Minasyan, E-Mail: h.s.minasyanc@gmail.com Hydro-morphological: Hovakim Frunzikyan, h.frunzikyan@mail.ru
Responsible for functional check of sampling equipment	Institute: Hydrometeorology and Monitoring Center SNCO Chemical: Tigran Araqelyan, E-Mail: tigranarakelyan91@mail.ru Biological: Vardan Karyan, E-Mail: VHKaryan@gmail.com
Responsible for calibration of in situ measuring equipment	Institute: Hydrometeorology and Monitoring Center SNCO Tigran Araqelyan, E-Mail: tigranarakelyan91@mail.ru
Responsible for sample transport from the field to the laboratory	Institute: Hydrometeorology and Monitoring Center SNCO Chemical: Tigran Araqelyan, E-Mail: tigranarakelyan91@mail.ru Biological: Vardan Karyan, E-Mail: VHKaryan@gmail.com
Chemical analysis	
Laboratory analyses and data assessment	Institute: Hydrometeorology and Monitoring Center SNCO Contact person: Alina Zurnachyan E-Mail: alina.zurnachyan@gmail.com Anna Zatikyan (Head *of Information Analytical Service*) E-Mail: anna_zatikyan@hotmail.com Ruzanna Avdalyan (Chief specialist at surface water quality monitoring service) E-Mail: avdalyanruzanna13@gmail.com
Biological analysis	
Overall responsible for the biological analysis in the lab, including reporting and data delivery	Institute: Hydrometeorology and Monitoring Center SNCO Contact person: Vardan Karyan (Head of soil, sediment and hydrobiological monitoring service) E-Mail: VHKaryan@gmail.com

2.4. Quality elements

Three quality elements have been chosen:

- Macroinvertebrates (= macrozoobenthos) and diatoms as biological quality element;
- General physico-chemical parameters (specific relevant pollutants such as heavy metals), list of parameters see Table 4;

- Hydromorphology for site description, hydrological measurements

Table 4. Parameters analyzed in the field and in the laboratory

Parameter	Unit
Field measurements	
Water temperature (WT)	°C
Oxygen concentration (DO)	mg/L
Oxygen saturation (O_2-Sat)	%
pH	
Electric conductivity (EC)	µS/cm
Laboratory analyses	
Total suspended solids (TSS)	mg/L
Biological oxygen demand (BOD_5)	mg/L
Chemical oxygen demand ($K_2Cr_2O_7$) (COD)	mg/L
Ammonia-N (NH_4-N)	mg/L
Nitrate-N (NO_3-N)	mg/L
Nitrite-N (NO_2-N)	mg/L
Orthophosphate, as P (PO_4-P)	mg/L
Total phosphorus (TP)	mg/L
Chloride (Cl)	mg/L
Sulphate, total ion (SO_4)	mg/L
Calcium (Ca)	mg/L
Magnesium (Mg)	mg/L
Sodium (Na)	mg/L
Potassium (K)	mg/L
Lithium (Li)	mg/L
Beryllium (Be)	mg/L
Boron (B)	mg/L
Aluminum (Al)	mg/L
Titanium (Ti)	mg/L
Vanadium (V)	mg/L
Chromium (Cr)	mg/L
Iron (Fe)	mg/L
Manganese (Mn)	mg/L
Cobalt (Co)	mg/L

Parameter	Unit
Nickel (Ni)	mg/L
Copper (Cu)	mg/L
Zink (Zn)	mg/L
Arsenic (As)	mg/L
Selenium (Se)	mg/L
Strontium (Sr)	mg/L
Molybdenum (Mo)	mg/L
Cadmium (Cd)	mg/L
Tin (Sn)	mg/L
Antimony (Sb)	mg/L
Barium (Ba)	mg/L
Lead (Pb)	mg/L

3. Methods

3.1. Sampling methods

The sampling was conducted by the field team (refer to Table 2). Water samples were taken following the requirements of ISO 5667-1:2018 and General Manual for Surveys in Running Waters (EUWI+, ENI/2016/372-403). High-density polyethylene (HD PE) containers were used for collecting water samples for chemical analysis. The laboratory provided sampling containers, filtration units, and preservation substances (if necessary), all clearly labeled for easy attribution to the sampling site and river.

To prevent bias effects from stirred-up sediment, water samples for chemical analyses were taken before collecting biological samples. Before filling the sampling bottle, it was rinsed with sample water, and samples were generally taken by hand at mid-height between the surface and bottom for optimal representativeness.

Immediately after sampling, all bottles were placed in cooling boxes, preservation and handling of water samples were conducted following the requirements of ISO 5667-3:2018.

The surface water samples were transported to HMC laboratory for the further processing and analysis. The handover process was documented using “Protocol for the delivery and handover of samples” (see attached Annex 5).

Biological sampling: The benthic invertebrates were sampled using the multi-habitat sampling (MHS) method developed during EU AQEM and STAR projects.

The whole sample from 10 to 20 (depending on the sampling site characteristics) single samples from every sampling site was taken to the laboratory for further analysis. Rare and endangered animals such as large mussels or crayfish were picked out, documented in the field, and released again.

Samples were fixed with a formaldehyde solution. The samples were stored in the cooling box and delivered to the laboratory for sorting and identification.

Diatoms (Bacillariophyceae) are the most important class of phytobenthos and comprise several thousand species. Sampling in wadable rivers follows the standard EN 13946 “Water Quality - Guidance for the routine sampling and preparation of benthic diatoms from rivers and lakes”. The sample was preserved by buffered formaldehyde solution and transferred to the laboratory in a cool box.

The transportation of the samples was done in accordance with the laboratory standard procedures. During transport, the samples for the chemical analyses were kept in coolers.

3.2. Laboratory analyses

3.2.1. Physico-chemical and chemical analyses

Analysis was conducted on 38 general physico-chemical parameters and heavy metals for each of the 25 water samples. The sampling team measured 5 parameters – Water temperature, Oxygen concentration, Oxygen Saturation, Electric conductivity and pH – on site in the field. The water samples were provided to the laboratory by the field team at every two days and were included in the test report.

The physico-chemical parameters were measured by the appropriate ISO standard methods (Table 5):

Table 5. List of field and laboratory methods

Parameter	Unit	LOD	LOQ	Standards
Field measurements				
Water temperature (WT)	°C			
Oxygen concentration (DO)	mg/L			ISO 5814
Oxygen saturation (O_2-Sat)	%			ISO 10523:
pH	-			ISO 10523
Electric conductivity (EC)	µS/cm			ISO 7888
Laboratory analyses				
Water temperature (WT, lab control)	°C			
Oxygen concentration (DO, lab control)	mg/L			ISO 5814
Oxygen saturation (O_2-Sat, lab control)	%			ISO 5814
pH (lab control)	-			ISO 10523
Electric conductivity (EC, lab control)	µS/cm			ISO 7888
Total suspended solids (TSS)	mg/L			ISO 11923
Biological oxygen demand (BOD_5)	mg/L			ISO 5815
Chemical oxygen demand ($K_2Cr_2O_7$)	mg/L			ISO 6060
Ammonia-N (NH_4-N)	mg/L	0.003	0.005	ISO 7150-1
Nitrate-N (NO_3-N)	mg/L	0.001	0.01	ISO 10304-1
Nitrite-N (NO_2-N)	mg/L	0.001	0.002	ISO 6777

Parameter	Unit	LOD	LOQ	Standards
Orthophosphate, as P (PO_4-P)	mg/L	0.001	0.002	ISO 6878
Total phosphorus (TP)	mg/L	0.005	0.01	ISO 17294
Chloride (Cl)	mg/L	0.025	0.05	ISO 10304-1
Sulphate, total ion (SO_4)	mg/L	0.125	0.25	ISO 10304-1
Calcium (Ca)	mg/L	0.005	0.01	ISO 17294
Magnesium (Mg)	mg/L	0.005	0.01	ISO 17294
Sodium (Na)	mg/L	0.005	0.01	ISO 17294
Potassium (K)	mg/L	0.005	0.01	ISO 17294
Lithium (Li)	mg/L	0.00005	0.0001	ISO 17294
Beryllium (Be)	mg/L	0.00005	0.0001	ISO 17294
Boron (B)	mg/L	0.0005	0.001	ISO 17294
Aluminum (Al)	mg/L	0.005	0.01	ISO 17294
Titanium (Ti)	mg/L	0.00005	0.0001	ISO 17294
Vanadium (V)	mg/L	0.00005	0.0001	ISO 17294
Chromium (Cr)	mg/L	0.00005	0.0001	ISO 17294
Iron (Fe)	mg/L	0.005	0.01	ISO 17294
Manganese (Mn)	mg/L	0.00005	0.0001	ISO 17294
Cobalt (Co)	mg/L	0.00005	0.0001	ISO 17294
Nickel (Ni)	mg/L	0.00005	0.0001	ISO 17294
Copper (Cu)	mg/L	0.00005	0.0001	ISO 17294
Zink (Zn)	mg/L	0.00005	0.0001	ISO 17294
Arsenic (As)	mg/L	0.00005	0.0001	ISO 17294
Selenium (Se)	mg/L	0.00005	0.0001	ISO 17294
Strontium (Sr)	mg/L	0.00005	0.0001	ISO 17294
Molybdenum (Mo)	mg/L	0.00005	0.0001	ISO 17294
Cadmium (Cd)	mg/L	0.00005	0.0001	ISO 17294
Tin (Sn)	mg/L	0.0005	0.001	ISO 17294
Stibium (Sb)	mg/L	0.00005	0.0001	ISO 17294
Barium (Ba)	mg/L	0.005	0.01	ISO 17294
Lead (Pb)	mg/L	0.00005	0.0001	ISO 17294

The analyses record includes the sampling date and the analyses date ensuring compliance with the attached manual on sample preservation.

3.3. Biological analyses

All specimens were picked out of the sediment sample and stored for later validation in vials with formalin. The invertebrates were separated to the major taxonomic groups and identified to the appropriate taxonomic level. The sorting of macroinvertebrate samples was adapted to meet the requirements of the STAR project (www.eu-star.at).

The ecological status was calculated following the Ecological Status Classification System (ESCS) developed by EUWI+. The ECSC system considers the composition and abundance of taxa, the ratio of disturbance-sensitive taxa to insensitive taxa, the level of diversity and the occurrence of major taxonomic groups (EUWI+ RefCond reports).

The literature used for determination was:

- Taxonomie für die Praxis, Bestimmungshilfen - Makrozoobenthos (1), LANUV-Arbeitsblatt 14, Recklinghausen 2010
- Taxonomie für die Praxis, Bestimmungshilfen - Makrozoobenthos (2), LANUV-Arbeitsblatt 20, Recklinghausen 2015
- Atlas of Central European Trichoptera Larvae, Johann Waringer, Wolfram Graf, 2011
- Identification Guide to Aquatic and Semiaquatic Diptera Larvae, German Limonological Society, 2015
- Chironomidae of the Holarctic Region, Keys and diagnoses – Larvae, Lund, Sweden, 2013
- Полевой определитель пресноводных беспозвоночных, Калининград 2002 (Field guide for freshwater invertebrates, Kaliningrad 2002)
- Süßwassermollusken, Peter Glöer, 2017
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3.3.1. Quality assurance

All the analyses were done in a professional manner and in accordance with the laboratory accreditation procedures. The transport storage, preservation and the chemical analyses were undertaken according to the laboratory accredited procedures together with the application of internal analytical quality controls.

4. Results and Discussion

4.1. Field protocols

The sampling team made the field protocols (Annex 1) for each surface water sample (from 25 sample sites). The protocols include detailed information about river basin, name and type, site number and coordinates, sampling date and time, weather and water quality conditions, name of surveyor with signature and other comments.

4.2. Water quality assessment- physico-chemical parameters

The results of the physico-chemical analyses are provided in Excel format as Annex 4.

The water quality was assessed based on the national water quality norms. The national water quality norms were defined according to the provisions of RA Government Decree №75-N "On establishing the norms for assuring water quality of each river basin district, depending upon local peculiarities" (27 January, 2011). The classification system is expressed in quality classes and the assessment is based on the same principle as Water Framework Directive (WFD), i.e., the "one out, all out" principle. Thus, the classification is given by the indicator of worst quality and when different water quality parameters fall into different classes, the final result considers the worst one.

The assessment system comprehends five classes for each water quality indicator: excellent (1st class), good (2nd class), moderate (3rd class), poor (4th class) and bad (5th class). The list of quality indicators contains about 37 chemical and physic-chemical indicators.

The national water quality norms for Debed and Aghstev Rivers are given in Annex 8 to this report.

The results of water quality assessment based on physicochemical parameters is presented in Table 6.

Table 6. Water quality at the sampling sites of the Northern WBMA based on chemical parameters

RBD	*Water object*	*Sampling site*	*Water quality indicator*	*Water quality class*	*Water quality based on chemical parameters*
Debed	*Chichkhan*	*Shirakamut (CS)*	*-*	*Good*	*Good*
	Lernajur	*Lernapat (LL)*	*-*	*Good*	*Good*
	Tandzut	*Antarashen (TA)*	*Al, SS*	*Moderate*	*Moderate*
		Vanadzor (TV)	*Cu, Al*	*Moderate*	*Poor*
			SS	*Poor*	
	Dzoraget	*Above Katnarat village (363)*	*-*	*Good*	*Good*
		Novoselovo village (DN)	*-*	*Good*	*Good*
		river mouth (10)	*Mo, V*	*Moderate*	*Moderate*
	Katnaghbyur	*River mouth, Armanis village (366)*	*NH_4, SS*	*Moderate*	*Bad*
			Zn, Cd, Mn, Co	*Bad*	
	Urut	*Bovadzor (UB)*	*Fe, Al, SS*	*Moderate*	*Moderate*

RBD	Water object	Sampling site	Water quality indicator	Water quality class	Water quality based on chemical parameters
	Martsiget	Atan (MA)	-	Good	Good
	Alareks	Above Debed village (361)	Mo	Poor	Poor
	Shereq	Jivanq (SJ)	Mo	Moderate	Moderate
	Lalvar	river mouth (368)	Zn, Pb, Mn, sulfate ion	Moderate	Bad
			Al, SS	Poor	
			Cu, Fe	Bad	
	Sedvi	Alaverdi (SA)	Mo	Moderate	Moderate
	Akhtala	river mouth (14)	NH_4, Cu, Mo, Fe, Ca, TDS	Moderate	Bad
			Mn	Poor	
			Sulphate ion	Bad	
	Nahatak	Mets Ayrum (river mouth) (373)	NH_4, Mn, Mg, B, TDS	Moderate	Bad
			Na, Ca, Fe, NO_3,	Poor	
			Mo, SO_4,	Bad	
	Debed	Qarkop (370)	Cu, Mn, Fe	Moderate	Poor
			Mo	Poor	
	Shnogh	Above Teghut village (ST)	COD, V, Fe, Al, SS	Moderate	Moderate
		river mouth (343)	COD, NH_4	Moderate	Bad
			Mo, Fe, Al,	Poor	
			Cu, SS	Bad	
	Debed	Bagratashen (7)	Mo, Fe, Al	Moderate	Bad
			SS	Bad	
Aghstev	Aghstev	Lermontovo (Ag)	-	Good	Good
		2 km below Ijevan city (18)	COD, V, Co, Ba, Al	Moderate	Bad
			Fe	Poor	
			SS	Bad	
	Bareber	Barepat (BB)	Fe, Ba	Moderate	Poor
			SS	Poor	
	Paytajur	Gandzasar (PG)	Ba, Al	Moderate	Poor
			Fe, SS	Poor	
	Samajur	Getahovit (SG)	COD, V, Co, Al	Moderate	Bad
			Fe	Poor	
			SS	Bad	

Debed RBD

Chichkhan, Lernajur, and Tandzut are tributaries of the **Pambak** River. Among these, Chichkhan (CS) and Lernajur (LL) sites have been designated as candidate reference sites and are classified as having "Good" water quality.

However, at the sampling site (TA) in the Tandzut River, the water quality is classified as "Moderate", primarily due to elevated levels of aluminum (0.594 mg/l) and suspended solids (36.9 mg/l).

At the sampling site (TV), the water quality is classified as "Poor," primarily due to high levels of suspended solids (89.4 mg/l), attributed to the influence of the Tandzut abandoned mining site.

Alareks river (#361) was intended as a candidate reference site, but molybdenum (Mo) concentration is very high (0.005 mg/l) and in terms of this the water quality of Alareks river is “Poor” quality.

The pH of the Pambak River has ranged from 7.81 to 8.46.

Dzoraget river

Two monitoring sites (363) and (DN), located upstream of Dzoraget river, are classified as “Good” quality, but at the mouth of the river (sampling site 10) in terms of content molybdenum (0.00153mg/l) and vanadium (0.0064mg/l) – “Moderate”. Comparing the mouth of Dzoraget river data with the upstream data, we have the following result: BOD_5 increased by 1.4 times, NO_3-N - 6.8, PO_4-P – 20, total phosphorus (TP) – 3.7, chloride and sulfate ions 7 and 5 times, respectively, for heavy metals: copper (Cu) increased by approximately 4 times, zinc (Zn), arsenic (As) and molybdenum (Mo) 46, 9.7 and 8.5 times, respectively. At the mouth of river Dzoraget, the pH is 8.66 and is under influence of settlements and the HPP.

The presence of such high concentrations of heavy metals is possibly due to both flooding and mining pressures.

Urut (site UB) and Katnaghbyur (site 366) are tributaries of Dzoraget river.

Urut tributary water quality is “Moderate” due to high concentration of Fe (0.674 mg/l), Al (0.716 mg/l), SS (47.3 mg/l). It could be the result of more floods.

The water quality of Katnaghbyur tributary is “Bad” due to influence of Armanis mining. The concentration suspended solids (SS) is 33.5 mg/l, pH is 8.03, NH4-N – 0.521 mg/l, in terms of these heavy metal content: zinc (Zn), cadmium (Cd), manganese (Mn), cobalt (Co) – 0.530 mg/l, 0.00650 mg/l, 2.786 mg/l, 0.0116 mg/l, respectively, the qualty of Katnaghbyur river is classified as bad.

Marts river is a one of right tributary of Debed river. The reference monitoring site of Marts river (MA) is located above the village of Atan and is classified as "Good" class.

Sedvi river is intended as an analogous river for Lalvar, Akhtala and Nahatak rivers. The water quality of Sedvi river is classified as “Moderate”, due to molybdenum (0.00164 mg/l).

Lalvar river is a left tributary of Debed river. Lalvar river is influenced by the abandoned mines of Madan and Alaverdi as well as the Arsenic graveyard. Dut to that the water quality of Lalvar river is “Bad”, in terms of content copper (0.155 mg/l) and iron (2.263 mg/l), “Moderate” – aliuminium (1.017 mg/l) and suspended solids (78.1 mg/l) and “Moderate” – zinc (0.175 mg/l), lead (0.0152 mg/l), manganese (0.104 mg/l) and sulfate ion (136.721 mg/l), pH is 8.13.

Shereq tributary is intended as an analogous river for Snogh River (without mining activity). Water quality of Shereq tributary is “Moderate” class, due to Mo concentration is 0.00218 mg/l. It is assumed that the reason is in the geological-chemical aspect.

Akhtala river is the left tributary of Debed river. Akhtala river is influenced by the mines of Akhtala and Shamlugh, of course with "Bad" quality of water. The amount of total suspended solids in the river is 7320.9 mg/l, which is due to flooding. According sulfate ion (302.027 mg/l) the quality of water is "Bad" class, due to manganese (0.219 mg/l) – "Poor", NH_4-N (0.656 mg/l), Cu (0.0311 mg/l), Mo (0.00287 mg/l), Fe (0.619 mg/l) – "Moderate".

Nahatak river is the left tributary of Debed river. It is influenced by Akhtala mines and flows out of Nahatak tailing dump. According Mo (0.021 mg/l), SO_4 (689.32 mg/l), the water quality is "Bad" class.

Shnogh river

Reference site (ST) of Shnogh river located 2km above village of Teghut. According COD (30 mgO/l), V (0.00672 mg/l), Fe (0.813 mg/l), Al (0.937 mg/l), SS (37.2 mg/l), the quality water is "Moderate" class. It is obvious that as a result of the flood, the high concentration of these elements, the soil from the banks of the river was filled and was mixed in the river.

Shnogh river mouth (site 343) is influenced by the mine of Teghut. According of data Cu (0.148 mg/l) and SS (450.2 mg/l), the quality of water is classified as "Bad", Mo (0.00452 mg/l), Fe (1.086 mg/l), Al (1.032 mg/l) – as "Poor", COD (40 mgO/l), NH_4-N (0.417 mg/l) – as "Moderate" class.

Debed river

Debed river (sampling site 370) located in Qarkop, is influenced by the mine of Akhtala and Nahatak tailing dump. The water quality is classified as "Poor", based on Mo content (0.00323 mg/l) and as "Moderate" based on Cu (0.0285 mg/l), Mn (0.0975 mg/l), Fe (0.518 mg/l) content.

Debed river site number 7 is the border sampling site with Georgia. The water quality is classified as "Bad" based on suspended solids (319.9 mg/l) and as "Moderate" based on Mo (0.00160 mg/l), Fe (0.809 mg/l), Al (0.390 mg/l) concentration.

Aghstev River Basin

Aghstev river

Above village of Lermontovo, Chr-chr waterfall (site Ag) is reference site for Aghstev river, and water quality is classified as "Good".

The sampling site 18 is located 2 km below to Ijevan city, on the Aghstev river, under the influence of Ijevan city. Based on SS (178.0 mg/l) it was classified as "Bad" class.

Paytajur river (sampling site PG) is located above villag of Gandzaqar. It was intended as a possible reference site for Aghstev river, and water quality is classified as "Poor" based on Fe (0.654 mg/l), SS (70.6 mg/l) content.

Sarnajur river (sampling site SG) is located above villag of Getahovit. It was intended as a possible reference site for Aghstev river, and water quality is classified as "Bad" based on SS (344.5 mg/l) content.

Bareber river (sampling site BB) is located above villag of Barepat. It was intended as a possible reference site for Getik river, and water quality is classified as "Poor" based on SS (68.6 mg/l) content.

4.3. Biological analyses

The invertebrates are separated to the major taxonomic groups and identified to the appropriate taxonomic levels. The results of biological survey are provided as Excel table in Annex 6 and the evaluated results are summarized in Table 7.

Table 7. Ecological Status at the sampling sites

Water object	*Observation point*	*Site No.*	*Type of sampling site*	*Nr. of taxa*	*Total abundance [m²]*	*nEQR*	*Ecological status*
Chichkhan	*Shirakamut*	*CS*	*R*	*24*	*736*	*1.00*	*High*
Lernajur	*Lernapat*	*LL*	*R*	*24*	*1514*	*1.00*	*High*
Tandzut	*Antarashen*	*TA*	*R*	*16*	*270*	*1.00*	*High*
	Vanadzor	*TV*	*I*	*14*	*32*	*0.74*	*Good*
Dzoraget	*Above Katnarat village*	*363*	*R*	*20*	*1124*	*0.74*	*Good*
	Novoselovo village	*DN*	*R*	*25*	*1065*	*1.00*	*High*
	river mouth	*10*	*I*	*10*	*62*	*0.60*	*Good*
Katnaghbyur	*River mouth, Armanis village*	*366*	*I*	*0*	*0*	*0.00*	*Bad*
Urut	*Bovadzor*	*UB*	*R*	*21*	*491*	*1.00*	*High*
Martsiget	*Atan*	*MA*	*R*	*17*	*274*	*0.78*	*Good*
Alareks	*Above Depet village*	*361*	*R*	*18*	*196*	*1.00*	*High*
Shereq	*Jivanq*	*SJ*	*R*	*17*	*160*	*1.00*	*High*
Lalvar	*river mouth*	*368*	*I*	*0*	*0*	*0.00*	Bad
Sedvi	*Alaverdi*	*SA*	*I*	*13*	*62*	*1.00*	*High*
Akhtala	*river mouth*	*14*	*I*	*0*	*0*	*0.00*	*Bad*
Nahatak	*River mouth, Mets Ayrum*	*373*	*I*	*3*	*58*	*0.14*	*Bad*
Debed	*Qarkop*	*370*	*I*	*8*	*14*	*0.29*	*Poor*
Shnogh	*Above Teghut village*	*ST*	*R*	*21*	*226*	*1.00*	*High*
	river mouth	*343*	*I*	*6*	*30*	*0.26*	*Poor*
Debed	*Bagratashen*	*7*	*I*	_	_	_	_
Aghstev	*Lermontovo*	*Ag*	*R*	*18*	*342*	*1.00*	*High*
	2 km below Ijevan	*18*	*I*	*11*	*51*	*0.39*	*Poor*
Bareber	*Barepat*	*BB*	*R*	*28*	*667*	*1.00*	*High*
Paytajur	*Gandzasar*	*PG*	*I*	*18*	*280*	*0.56*	*Moderate*
Sarnajur	*Getahovit*	*SG*	*I*	*12*	*90*	*0.85*	*High*

(R=reference, I=influenced)

In rivers of Katnaghbyur (366), Lalvar (368) and Akhtala (14) no animals were found.

Debed River Basin

Pambak river

Chichkhan, Lernajur and Tandzut are tributaries of Pambak river.

Chichkhan (CS), Lernajur (LL) and Tandzut (TA) as reference sites classified as “High” Ecological status. Tandzut river at the sampling site (TV) is classified as having “Good” Ecological status after the influence of the Jangot Jur tributary which is under the influence of Tandzut abandoned mining site.

Alareqs river

The Alareqs river is one of the right tributaries of the Pambak river and was intended as a reference site, the Ecological status of Alareqs river is classified as “High”.

Dzoraget river

Two monitoring sites (363) and (DN), are located in the upstreams of the Dzoraget river. Dzoraget river in Novoselovo village site (DN) has a “High” Ecological status. Above Katnarat village (363) and at the mouth of the river (sampling site 10) are classified as “Good” Ecological status. The mouth of river Dzoraget is under the influence of settlements and the HPP.

Urut (site UB) and Katnaghbyur (site 366) are tributaries of Dzoraget river.

Urut tributary Ecological status is “High”.

The water quality of Katnaghbyur tributary is “Bad” due to influence of Armanis mining.

Marts river

The Marts river is a one of right tributary of Debed river. The reference monitoring site of Marts river (MA) is located above the village of Atan and is classified as "Good" Ecological status.

Sedvi river is intended as a possible reference site for the Lalvar, Akhtala and Nahatak rivers. The Ecological status of Sedvi river is classified as “High”.

Lalvar river is a left tributary of the Debed river. Lalvar river is influenced by the abandoned mines of Madan and Alaverdi as well as the Arse-nic graveyard. Due to that the Ecological status of the Lalvar river is “Bad”.

Shereq tributary

This site is intended as a possible reference site for the Shnogh river and the Ecological status of the Shereq tributary is classified as “High”.

Akhtala river

Akhtala river is the left tributary of the Debed river.

Akhtala river is influenced by the mines of Akhtala and Shamlugh, and the Ecological status of the Akhtala river is “Bad”.

Nahatak river is the left tributary of the Debed river. Nahatak river is influenced by the Akhtala mining factory, it is directly under the influence of the Nahatak tailing dump. It is interesting that until now macroinvertebrates have never been found in this sampling site, but this year we found 3 taxa with 36 individuals. The Ecological status of the Nahatak river is “Bad”.

Shnogh river

Reference site (ST) of Shnogh river located 2km above village of Teghut. The Ecological status of the is “High”.

Shnogh river mouth (site 343) is influenced by the mine of Teghut. The Ecological status is classified as “Poor”.

Debed river

Debed river site (370) located in Qarkop, is influenced by the mine of Akhtala and Nahatak tailing dump. The Ecological status is classified as “Poor”.

Debed river site number 7 is the border sampling site with Georgia. During fieldwork in June, heavy mudslides caused severe flooding in some rivers in the inner reaches of the Debed River basin. For this reason, sampling works were carried out at the sampling sites of those sites in July. However, it was not possible to carry out hydrobiological sampling in July at the Armenia-Georgia border sampling site - 7 due to the tightening of the border control service.

Aghstev River Basin

Aghstev river

Above village of Lermontovo, Chr-chr waterfall (site Ag) is reference site for Aghstev river, and Ecological status is classified as "High".

The sampling site 18 is located 2 km below to Ijevan city, on the Aghstev river, under the influence of Ijevan city. Ecological status is classified as "Poor" class.

Paytajur river (site PG) is located above villag of Gandzaqar. It was intended as a possible reference site for Aghstev river, and Ecological status is classified as "Moderate".

Sarnajur river (site SG) is located above villag of Getahovit. It was intended as a possible reference site for Aghstev river, and Ecological status is classified as "High".

Bareber river (site BB) is located above villag of Barepat. It was intended as a possible reference site for Getik river, and Ecological status is classified as "High".

4.4. Hydromorphological assessment

The field protocols with photos (JPG format) are provided as separate attachment in Annex 3 (Word format). The hydro-morphological assessment is provided in Annex 3.1 and 3.2 (Word format).

Table 8. Hydromorphological assessment of the survey units

River basin	River name	Date	Survey unit No	Site name	Hydrological status	Morphological status	Hy-Mo Status
Debed	Chichkhan	19/06/2023	CS	Shirakamut	1.0	1.5	1.3
Debed	Tandzut	26/06/2023	TA	Antarashen	1.0	1.5	1.3
Debed	Tandzut	26/06/2023	TV	Vanadzor	2.0	1.5	1.8
Debed	Lernajur	19/06/2023	LL	Lernapat	1.0	1.5	1.3
Debed	Dzoraget	20/06/2023	363	Katnarat	1.0	1.3	1.2
Debed	Dzoraget	20/06/2023	DN	Novoselcovo,	1.0	1.7	1.4
Debed	Katnaghbyur (river mounth)	20/06/2023	366	Armanis	2.5	1.6	2.1
Debed	Urut	20/06/2023	UB	Bovadzor	1.0	1.4	1.2
Debed	Dzoraget (river mounth)	17/07/2023	10	Dzoraget	3.0	1.4	2.2
Debed	Martsiget	20/07/2023	MA	Atan	2.3	1.3	1.8
Debed	Alareqs	17/07/2023	361	Debed	3.0	1.2	2.1
Debed	Lalvar (river mounth)	21/06/2023	368	Alaverdi	3.0	2.4	2.7
Debed	Sherenq	20/06/2023	SJ	Jivanq	2.5	1.4	2.0
Debed	Akhtala (river mounth)	22/06/2023	14	Akhtala	1.0	2.8	1.9

Debed	Nahatak	21/07/2023	373	Metc Ayrum	1.0	1.8	1.4
Debed	Debed	21/07/2023	370	Qarkop	3.0	1.98	2.5
Debed	Shnogh	22/06/2023	ST	Teghut	1.0	1.3	1.2
Debed	Shnogh (river mounth)	22/06/2023	343	Shnogh	3.5	1.8	2.7
Debed	Debed	22/06/2023	7	Bagratashen (border)	4.0	1.2	2.6
Debed	Sedvi	20/07/2023	SA	Alaverdi	2.5	1.5	2.0
Aghstev	Aghstev	26/06/2023	Ag	Lermontovo	1.0	1.4	1.2
Aghstev	Bareber	26/06/2023	BB	Barepat	2.0	1.5	1.8
Aghstev	Paytajur	27/06/2023	PG	Gandzaqar	2.0	1.9	2.0
Aghstev	Sarnajur	27/06/2023	SG	Getahovit	3.0	2.3	2.7
Aghstev	Aghstev	27/06/2023	18	Ijevan	3.0	1.9	2.5

Hydrological Assessment

Characterizations of the hydrological regime in respect of mean and low flow, flow range and flow fluctuation. This chapter should provide an overview of the single hydrological parameters and the overall hydrological score status including the identification of the drivers for an observed hydrological change. The quantitative parameters of each hydrology assessment category should be shown in Annex 3.1.

Table 9. Hydrological assessment

River basin/River name	Site name	Date	Survey unit No	Mean flow	Low flow	Water level range	Flow fluctuation	Hydro Score
Chichkhan	Shirakamut	19/06/2023	CS	1	1	1	1	1.0
Tandzut	Antarashen	26/06/2023	TA	1	1	1	1	1.0
Tandzut	Vanadzor	26/06/2023	TV	1	1	3	3	2.0
Lernajur	Lernapat	19/06/2023	LL	1	1	1	1	1.0
Dzoraget	Katnarat	20/06/2023	363	1	1	1	1	1.0
Dzoraget	Novoselcovo	20/06/2023	DN	1	1	1	1	1.0
Katnaghbyur (river mounth)	Armanis	20/06/2023	366	1	3	3	3	2.5
Urut	Bovadzor	20/06/2023	UB	1	1	1	1	1.0
Dzoraget (river mounth)	Dzoraget	17/07/2023	10	1	1	5	5	3.0
Marts	Atan	20/07/2023	MA	1	3	2	3	2.3
Alareqs	Debed	17/07/2023	361	1	1	5	5	3.0
Lalvar (river mounth)	Alaverdi	21/06/2023	368	1	3	3	5	3.0
Sherenq	Jivanq	20/06/2023	SJ	1	3	3	3	2.5
Akhtala (river mounth)	Akhtala	22/06/2023	14	1	1	1	1	1.0
Nahatak	Metc Ayrum	21/07/2023	373	1	1	1	1	1.0
Debed	Qarkop	21/07/2023	370	1	1	5	5	3.0
Shnogh	Teghut	22/06/2023	ST	1	1	1	1	1.0
Shnogh (river mounth)	Shnogh	22/06/2023	343	1	3	5	5	3.5

Debed	Bagratashen (border)	22/06/2023	7	3	3	5	5	4.0
Sedvi	Alaverdi	20/07/2023	SA	1	3	3	3	2.5
Aghstev	Lermontovo	26/06/2023	Ag	1	1	1	1	1.0
Bareber	Barepat	26/06/2023	BB	1	1	3	3	2.0
Paytajur	Gandzaqar	27/06/2023	PG	1	1	3	3	2.0
Sarnajur	Getahovit	27/06/2023	SG	1	1	5	5	3.0
Aghstev	Ijevan	27/06/2023	18	1	1	5	5	3.0

Morphological assessment

The morphological parameters cover four categories: channel form, instream features, bank/riparian zone and floodplain parameters. This chapter should provide an overview of the single morph parameters and the overall morphological status. The single parameters within each morph assessment category should be shown in Annex 3.2.

Table 10. Overview table of the single morphology parameters per survey unit

River basin/River name	Site name	Date	Survey unit No	Channel form	Instream features	Riparian zone	Floodplain	Morph Score
Chichkhan	Shirakamut	19/06/2023	CS	1.0	2.3	1.5	1.0	1.5
Tandzut	Antarashen	26/06/2023	TA	1.0	2.3	1.7	1.0	1.5
Tandzut	Vanadzor	26/06/2023	TV	1.0	2.3	1.6	1.0	1.5
Lernajur	Lernapat	19/06/2023	LL	1.0	2.2	1.9	1.0	1.5
Dzoraget	Katnarat	20/06/2023	363	1.0	1.8	1.3	1.0	1.3
Dzoraget	Novoselcovo	20/06/2023	DN	1.0	2.3	2.0	1.0	1.7
Katnaghbyur (river mounth)	Armanis	20/06/2023	366	1.0	2.1	1.4	2.0	1.6
Urut	Bovadzor	20/06/2023	UB	1.0	2.3	1.3	1.0	
Dzoraget (river mounth)	Dzoraget	17/07/2023	10	1.0	2.0	1.7	1.0	1.4
Marts	Atan	20/07/2023	MA	1.0	2.0	1.0	1.0	1.3
Alareqs	Debed	17/07/2023	361	1.0	1.8	1.0	1.0	1.2
Lalvar (river mounth)	Alaverdi	21/06/2023	368	1.0	2.8	4.7	1.0	2.4
Sherenq	Jivanq	20/06/2023	SJ	1.0	2.6	1.0	1.0	1.4
Akhtala (river mounth)	Akhtala	22/06/2023	14	1.0	3.0	4.7	2.5	2.8
Nahatak	Metc Ayrum	21/07/2023	373	1.0	2.3	1.0	3.0	1.8
Debed	Qarkop	21/07/2023	370	1.0	1.9	4.0	1.0	2.0
Shnogh	Teghut	22/06/2023	ST	1.0	2.0	1.0	1.0	1.3
Shnogh (river mounth)	Shnogh	22/06/2023	343	1.0	2.2	3.0	1.0	1.8
Debed	Bagratashen (border)	22/06/2023	7	1.0	1.9	1.0	1.0	1.2

Sedvi	Alaverdi	20/07/2023	SA	1.0	2.6	1.3	1.0	1.5
Aghstev	Lermontovo	26/06/2023	Ag	1.0	2.5	1.0	1.0	1.4
Bareber	Barepat	26/06/2023	BB	1.0	2.3	1.7	1.0	1.5
Paytajur	Gandzaqar	27/06/2023	PG	1.0	2.4	3.2	1.0	1.9
Sarnajur	Getahovit	27/06/2023	SG	1.0	2.5	4.5	1.0	2.3
Aghstev	Ijevan	27/06/2023	18	1.0	2.1	3.3	1.0	1.9

4.5. Analyzing trends in water quality parameter concentrations

The changes in concentrations of water quality parameters: 13 physico-chemical parameters and 22 heavy metals have been analyzed in each of the 25 water samples.

The concentration of dissolved oxygen and oxygen saturation were rated as "excellent" (class 1) at all observation points. The pH values range from 7.81 to 8.99.

Nutrients

The highest concentration of ammonium ion (Figure 2) was found in the rivers of Katnaghbyur (366), Nahatak (373) and Akhtala (14) ranked as “moderate” class respectively. In the remained sampling sites, the concentration of ammonium ion was assessed as "excellent” or "good" classes.

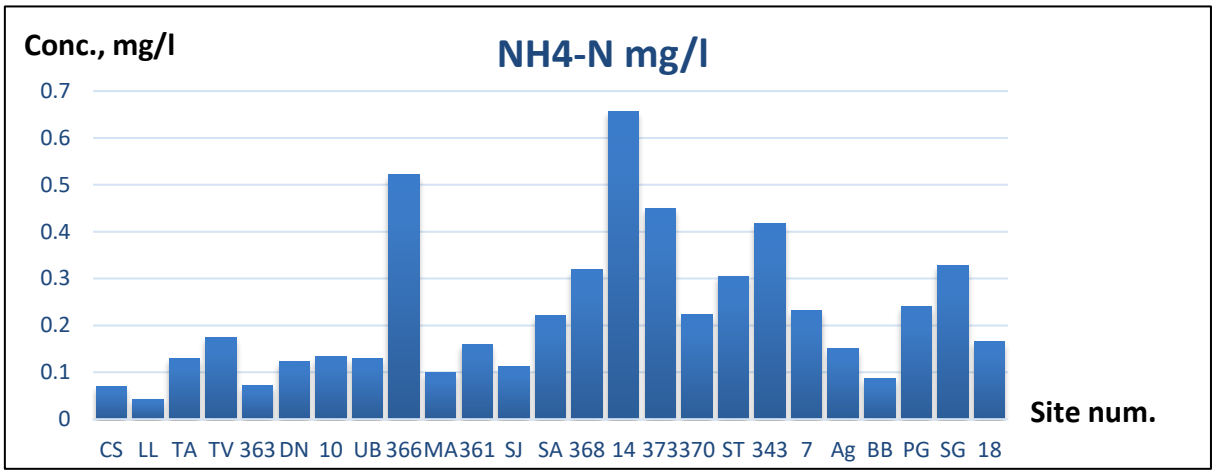

Figure 2. Ammonium ion concentration pattern in Northern WBMA

The concentration of nitrate ion (Figure 3), was relatively high in the Nahatak river (373) rated "moderate" class. In the remained sampling sites, the concentration of nitrate ion was assessed as "excellent” or “good" classes.

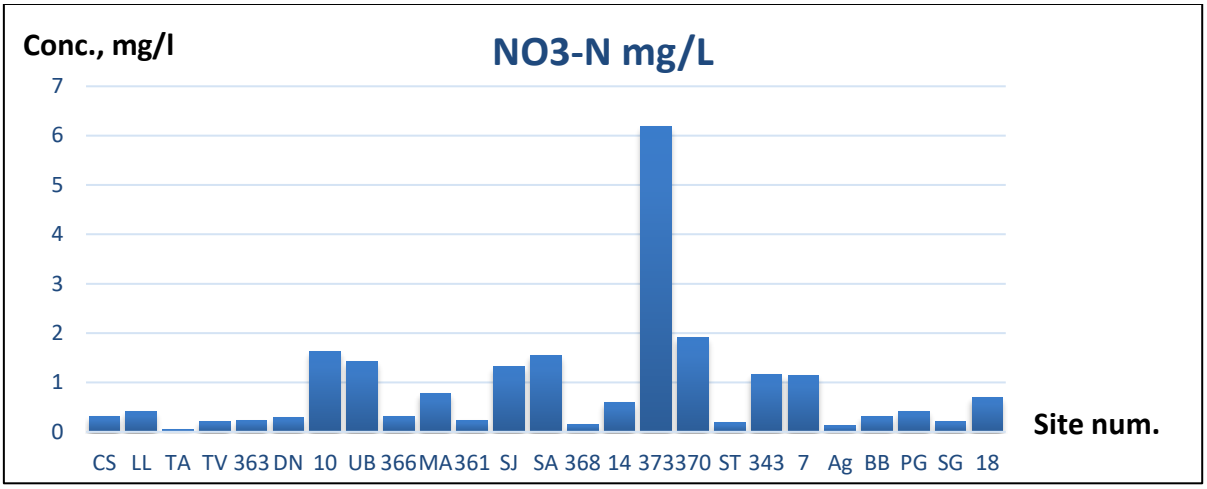

Figure 3. Nitrate ion concentration pattern in Northern WBMA

The concentration of phosphate ion (Figure 4) were rated "excellent in all sampling sites.

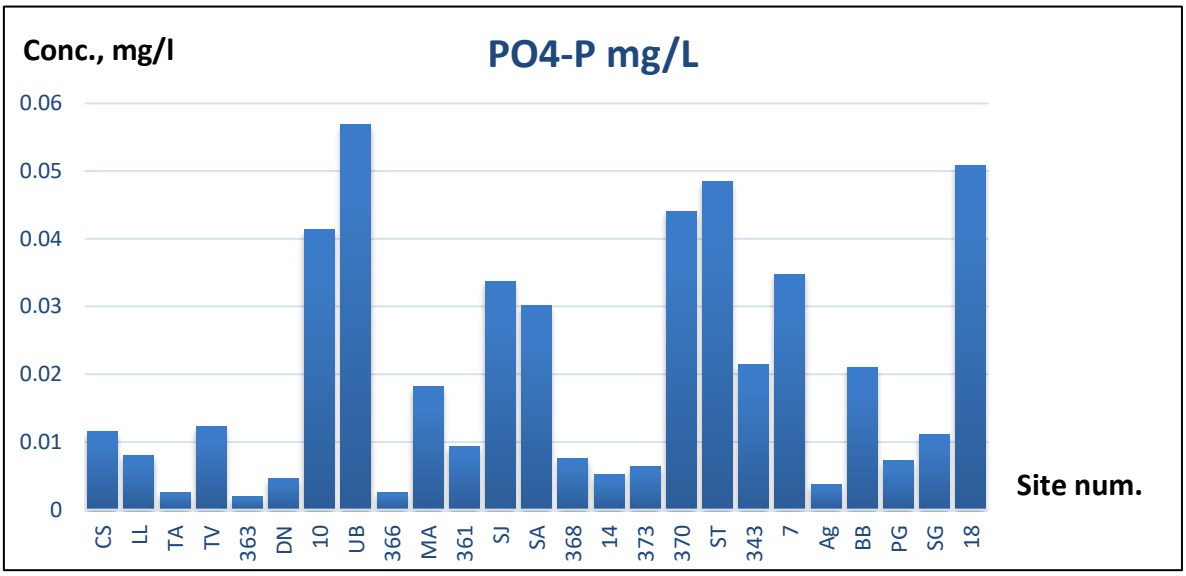

Figure 4. Phosphate ion concentration pattern in Northern WBMA

Sulfate ion concentrations were rated "bad" (class 5) in the rivers of Akhtala (14) and Nahatak (373). The "moderate" (class 3) in the river of Lalvar (368) was rated. In the remained sampling sites, the concentration of sulfate ion was assessed as "excellent" or "good" classes.

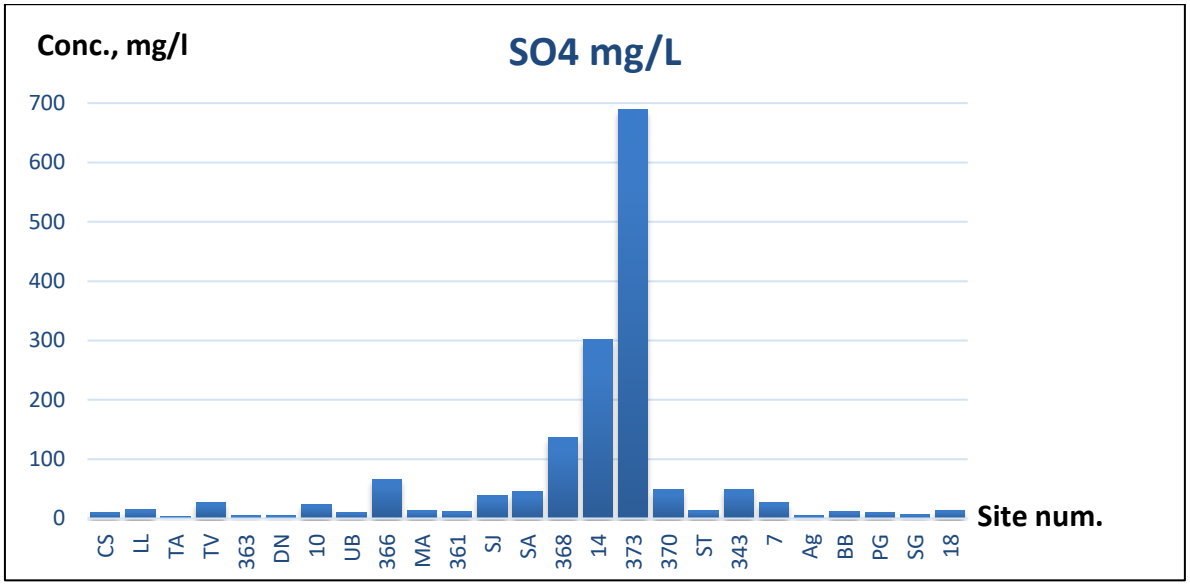

Figure 5. Sulfate ion concentration pattern in Northern WBMA

Saline conditions (cations and anions):

For all sampling sites chloride ion were rated "excellent" or "good" (class 1 or 2).

EC/TDS concentration was rated "moderate" (class 3) in the rivers of Akhtala (14) and Nahatak (373). In all other sampling sites were "excellent" or "good" (class 1 or 2).

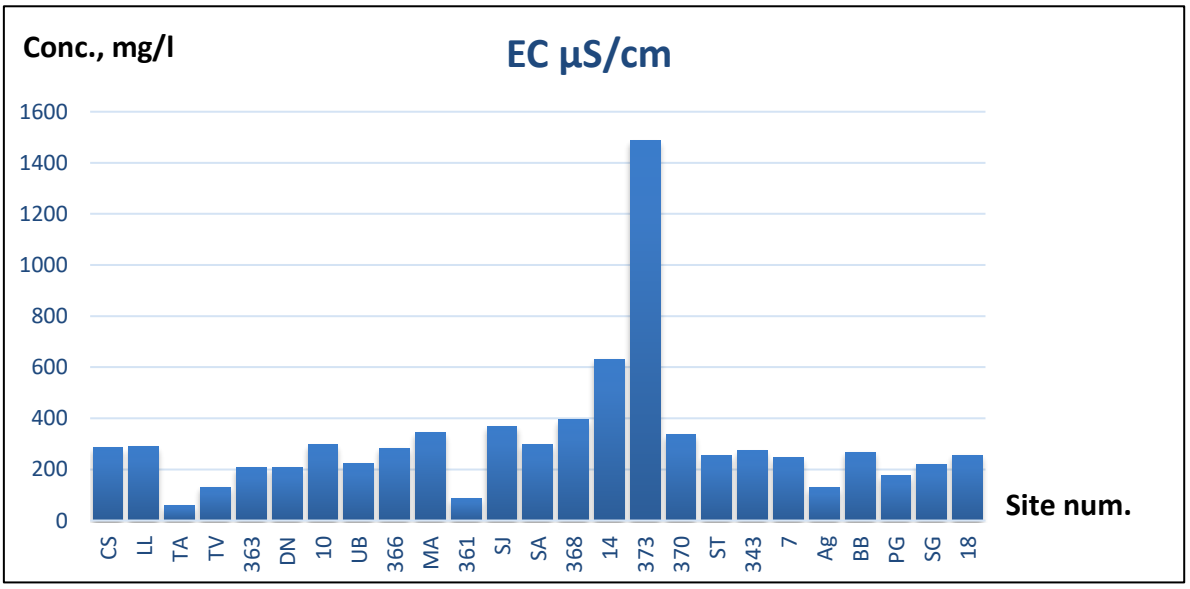

Figure 6. EC concentration pattern in Northern WBMA

TSS (Total suspended solids) concentrations were rated "bad" (class 5) in the rivers of Akhtala (14), Shnogh (343), Debed (7), Sarnajur (SG) and Aghstev (18). Moreover, the TSS value in Akhtala River (14) exceeds the limit value of class 5 by 61 times.

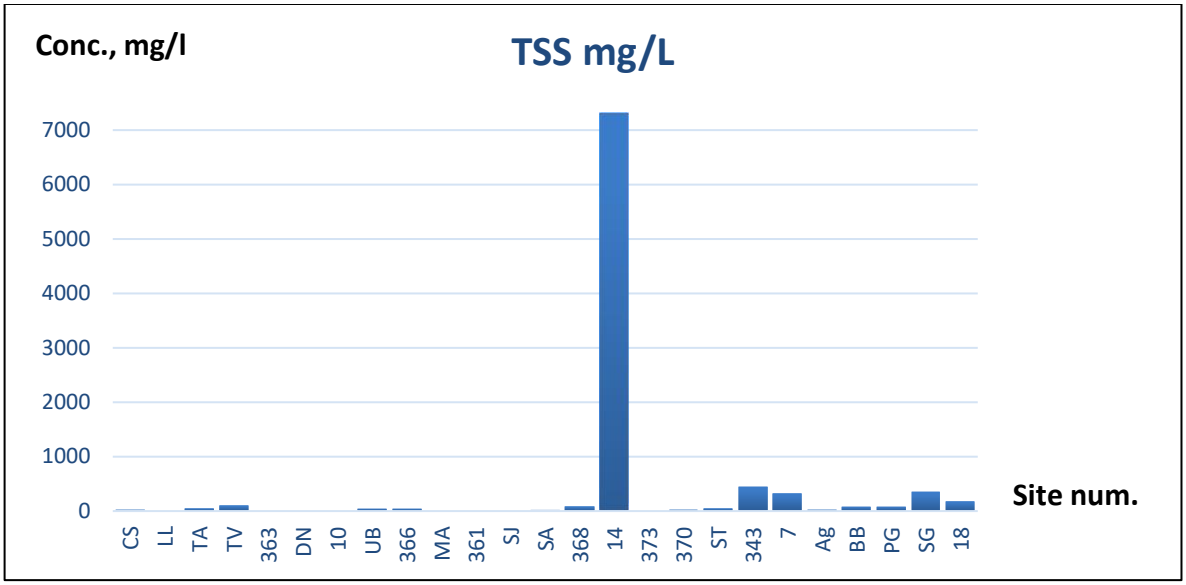

Figure 7. TSS concentration pattern in Northern WBMA

TSS concentration was rated "poor" (class 4) in the rivers of Tandzut (TV), Lalvar (368), Bareber (BB) and Paytajur (PG), and was rated "moderate" (class 3) in the rivers of Tandzut (TA), Urut (UB), Katnaghbyur (366) and Shnogh (ST) . In all other sampling sites were "excellent" or "good" (class 1 or 2).

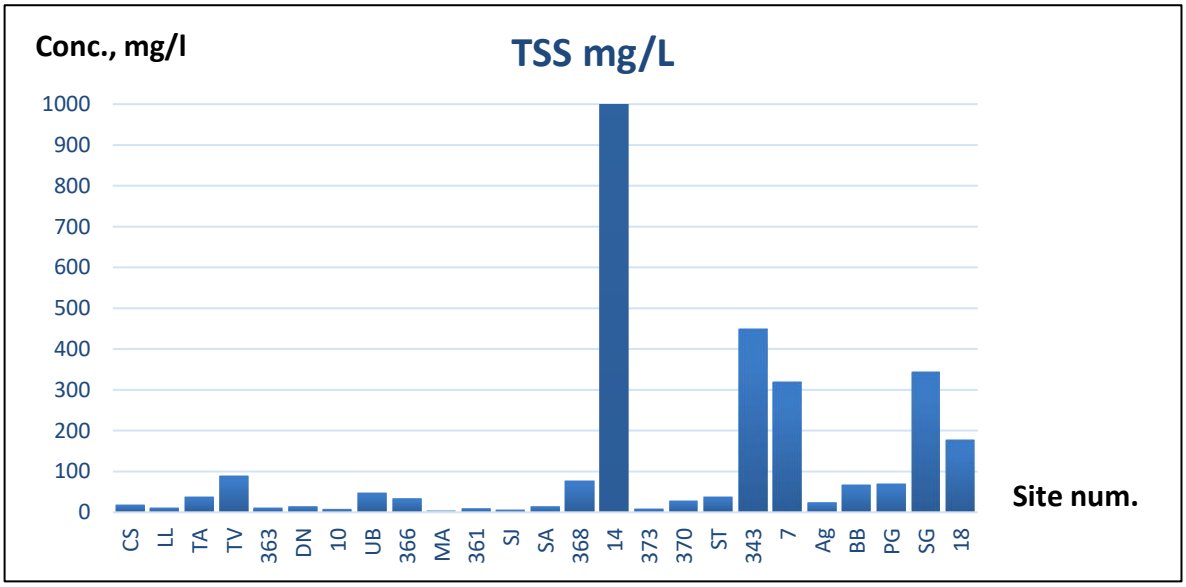

Figure 8. TSS concentration pattern in Northern WBMA

Heavy metals:

Water quality due to molybdenum concentration were rated (Figure 8) "moderate" (class 3) in the rivers of Debed (7) (near the border), Dzoraget (10), Shereq (SJ), Sedvi (SA) and Akhtala (14), "Poor" (class 4) in the rivers of Alareqs (361), Debed (370) (2.3 km after the spilling of the Nahatak river) and Shnogh (343), "bad" (class 5) in the river of Nahatak (373).

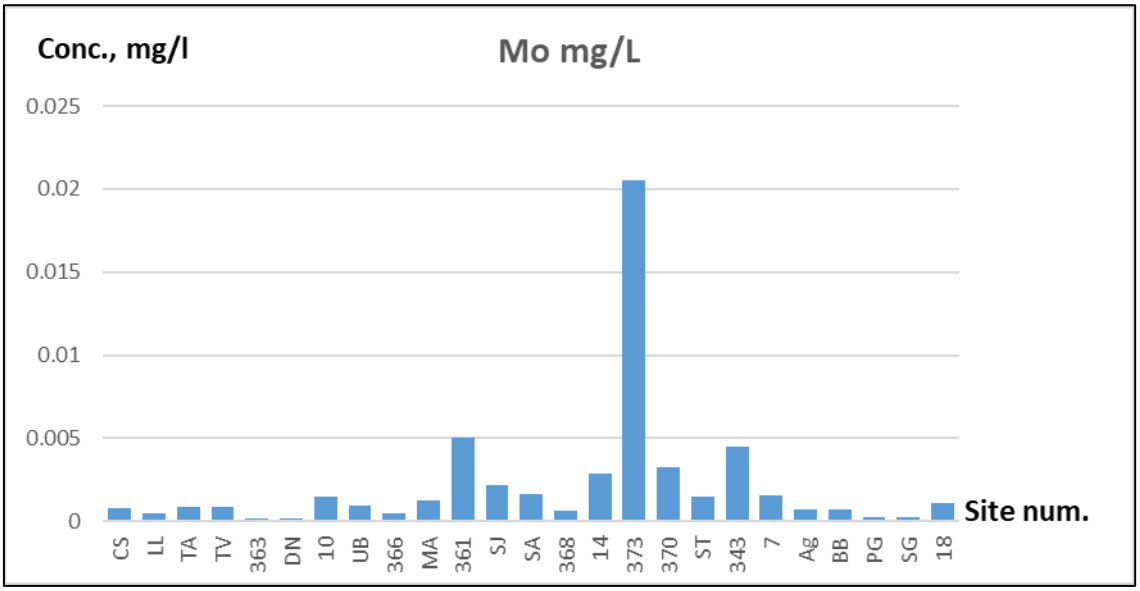

Figure 9. Mo concentration pattern in Northern WBMA

Cu concentrations (Figure 9) were rated “moderate” in the rivers of Tandzut (TV), Akhtala (14), Debed (370) (2.3 km after the spilling of the Nahatak river) and Debed (7) (near the border) and “bad” in the River of Lalvar (368) and Shnogh (343).

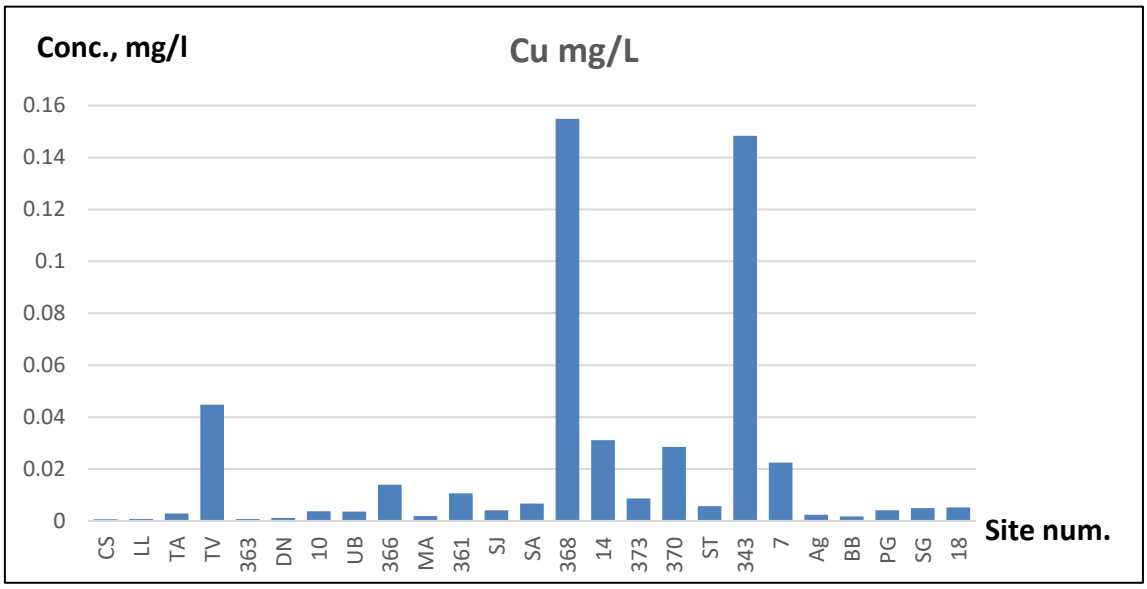

Figure 10. Cu concentration pattern in Northern WBMA

Zn concentrations were higher (10) in the river of Katnaghbyur (366) where water quality was classified "bad" (class 5) and “moderate” in the River of Lalvar (368).

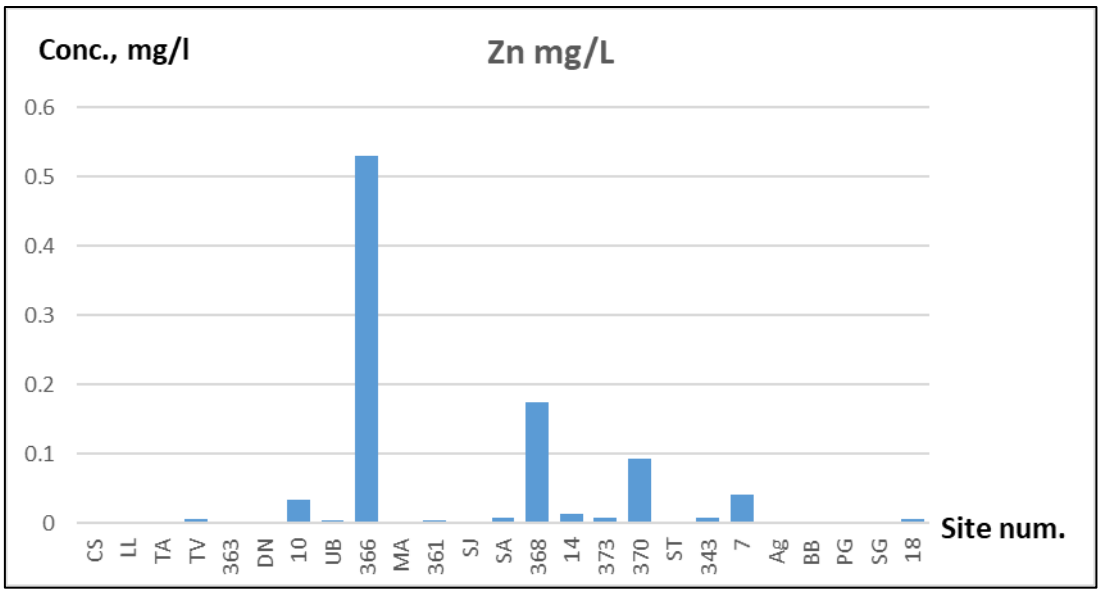

Figure 11. Zn concentration pattern in Northern WBMA

Water quality due to iron concentration was classified "bad" (class 5) in the rivers of Lalvar (368) and Tandzut (TV); as "poor" in the rivers of Nahatak (373) and Shnogh (343); as "moderate" in the rivers of Urut (UB), Akhtala (14), Debed (370) (2.3 km after the spilling of the Nahatak river) and Debed (7) (near the border) and Shnogh (ST).

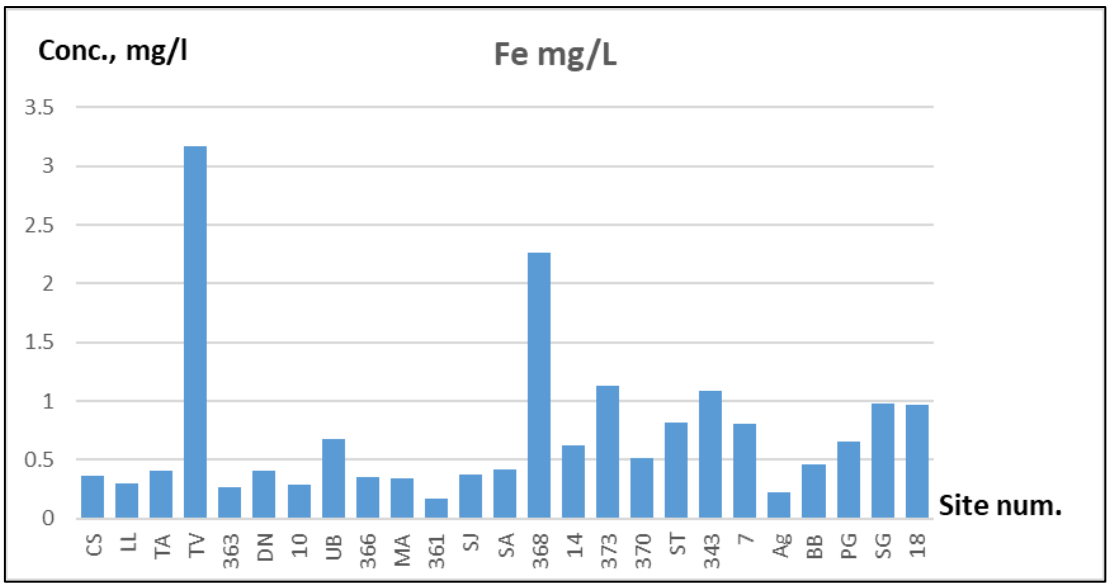

Figure 12. Fe concentration pattern in Northern WBMA

Water quality due to cadmium and cobalt concentration was classified "bad" (class 5) in the river of Katnaghbyur (366).

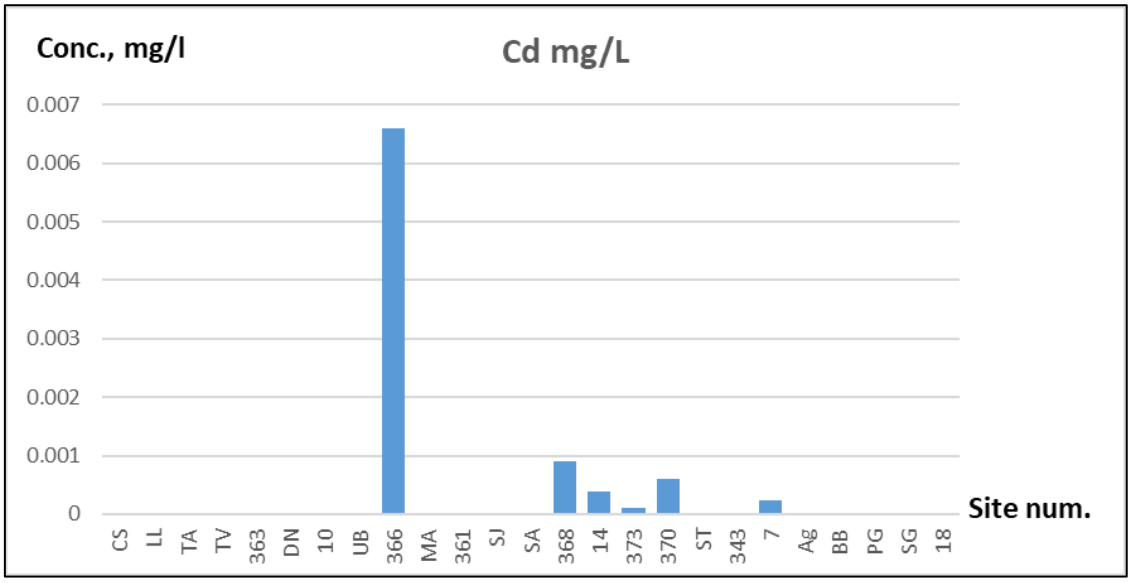

Figure 13. Cd concentration pattern in Northern WBMA

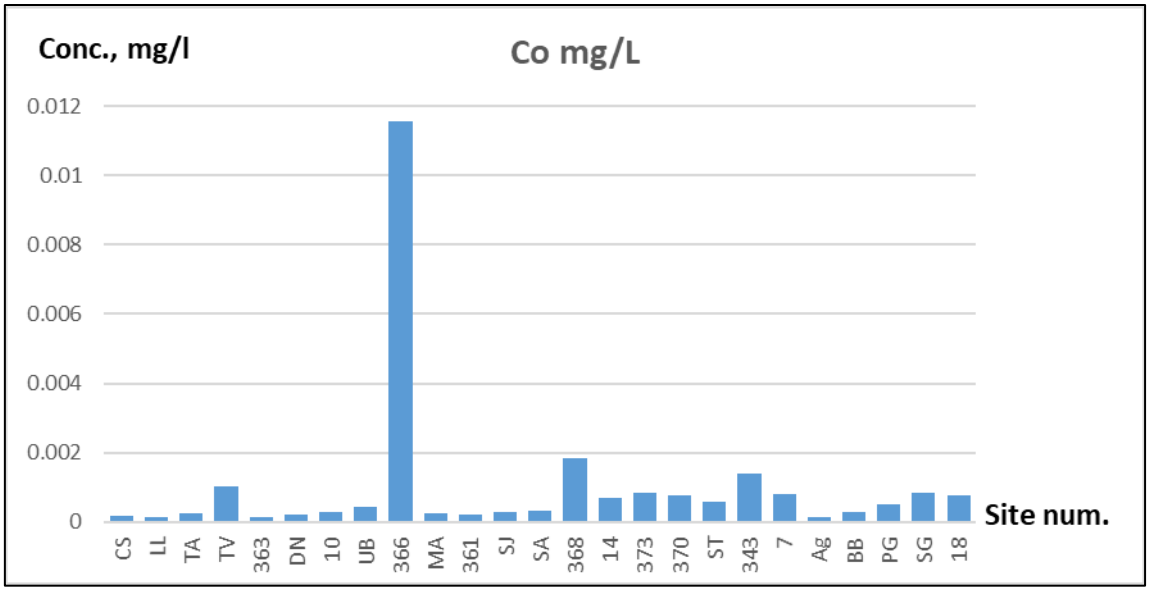

Figure 14. Co concentration pattern in Northern WBMA

Mn concentrations were higher (14) in the river of Katnaghbyur (366) where water quality was classified "bad" (class 5); "poor" in the river of Akhtala (14) and “moderate” in the rivers of Lalvar (368), Nahatak (373) and Debed (370) (2.3 km after the spilling of the Nahatak river).

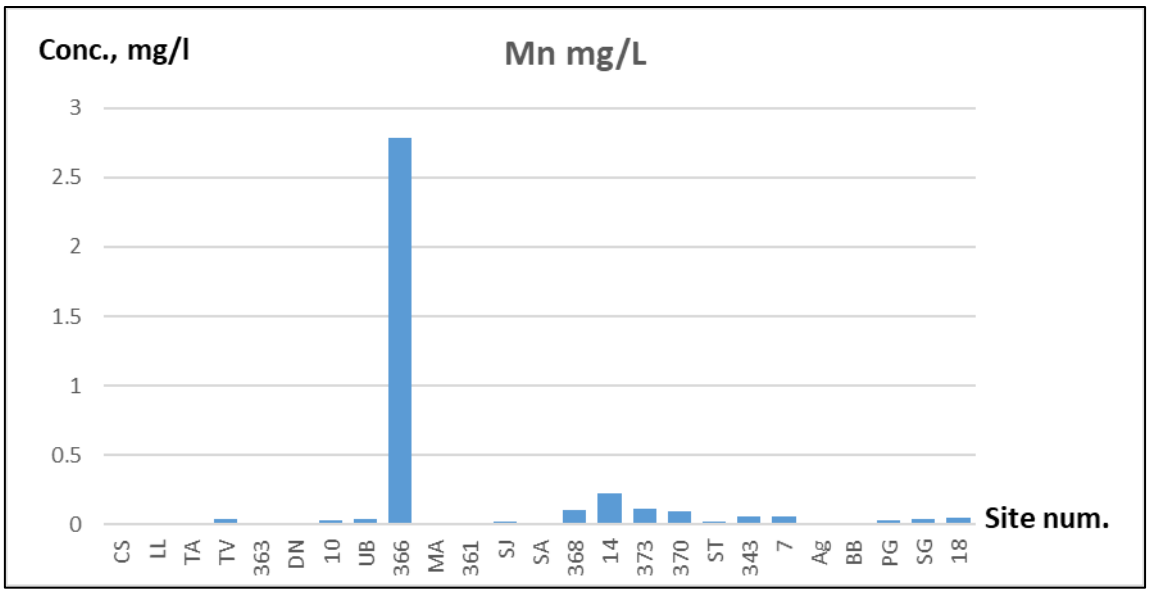

Figure 15. Mn concentration pattern in Northern WBMA

4.6. Water quality assessment

- Water quality based on chemical parameters is “bad” in 8 sampling sites at 8 rivers. At 5 sampling sites, the water quality is “poor”, whereas 6 sites each were classified as “moderate” and “good”.
- Basically, the classes of water quality based on biological and chemical parameters are different. Only, in 7 sampling sites both assessments were ranked in the same classes. The interesting thing is that the ecological status is higher than water quality class based on physicochemical parameters.

Table 11. Ecological status at the sampling sites

River	Site No.	*Type of sampling site*	Ecological status	Water quality based on chemical parameters	Hydromorpho-logical Status
Chichkhan	*CS*	*R*	*High*	*Good*	High
Lernajur	*LL*	*R*	*High*	*Good*	High
Tandzut	*TA*	*R*	*High*	*Moderate*	High
Tandzut	*TV*	*I*	*Good*	*Poor*	Good
Dzoraget	*363*	*R*	*Good*	*Good*	High
Dzoraget	*DN*	*R*	*High*	*Good*	High
Dzoraget	*10*	*I*	*Good*	*Moderate*	Good
Katnaghbyur	*366*	*I*	*Bad*	*Bad*	Good
Urut	*UB*	*R*	*High*	*Moderate*	High
Martsiget	*MA*	*R*	*Good*	*Good*	Good
Alareks	*361*	*R*	*High*	*Poor*	Good
Shereq	*SJ*	*I*	*High*	*Moderate*	Good
Lalvar	*368*	*I*	Bad	*Bad*	Moderate
Sedvi	*SA*	*I*	*High*	*Moderate*	Good
Akhtala	*14*	*I*	*Bad*	*Bad*	Good

Nahatak	*373*	*I*	*Bad*	*Bad*	High
Debed	*370*	*I*	*Poor*	*Poor*	Good
Shnogh	*ST*	*R*	*High*	*Moderate*	High
Shnogh	*343*	*I*	*Poor*	*Bad*	Moderate
Debed	*7*	*I*	_	*Bad*	Moderate
Aghstev	*Ag*	*R*	*High*	*Good*	High
Aghstev	*18*	*I*	*Poor*	*Bad*	Good
Bareber	*BB*	*R*	*High*	*Poor*	Good
Paytajur	*PG*	*R*	*Moderate*	*Poor*	Good
Sarnajur	*SG*	*R*	*High*	*Bad*	Moderate

(R=reference, I=influenced)

5. Conclusions and Lessons learned

- The survey conducted in 2023 June in Debed RBD, made it possible to form a sound methodological basis for future monitoring programs as an essential part of river basin management planning, providing data for the assessment of water quality status in Debed RBDs, providing data for the pressure-impact and risk assessment.
- Generally, the data obtained from hydrobiological surveys aligned with expectations. High ecological status was predominantly observed across all reference sampling sites, encompassing a total of 10 locations with exceptions noted at the source of the Dzoraget River above Katnarat village (363) and Martsiget above Atan village (MA) where the Ecological status was good and Paytajur River above Gandzasar village (PG) where the Ecological status was moderate. This may be due to the small amount of water and black soil in the area.
- Good ecological status was recorded at 4 sampling sites including above mentioned two reference sites: Tandzut Vanadzor (TV), Dzoraget above Katnarat village (363), Dzoraget mouth (10), and Martsiget above Atan village (MA).
- Moderate ecological status was registered at the sampling site of the Gandzasar village of the Paytajur River. This may be due to the small amount of water, black soil in the area and communal-domestic pressures.
- Poor ecological status was recorded at 2 sampling sites in the Debed River basin - Shnogh River mouth (343) and Debed River near the Qarkop settlement (370), and 1 sampling site located after the Ijevan city on the Aghstev River (18). The pressures here are both communal-domestic pressures and pressures caused by mining activity, but the influence of the interstate road as a source of diffuse pollution is not excluded.
- Bad ecological status was recorded at the 4 sampling sites, which are located exclusively in the Debed River basin and pressures on these sites are caused by mining activity: Katnaghbyur mouth (366), Lalvar (368), Akhtala (14) and Nahatak (373).
- It was revealed that water quality classes based on biological and chemical parameters are different. Only in 7 sampling sites both assessments were ranked in the same classes. The interesting thing is that the ecological status is higher than water quality class based on physicochemical parameters. The biological results show a need for evaluating and possibly revising the class boundaries for the chemical parameters.
- The following sampling sites designated as the candidate reference sites have been found not suitable for the purpose because of having “Moderate” to “Bad” status in terms of water quality: Sedvi river, Shereq tributary, Shnogh river reference site (ST), Paytajur river, Sarnajur river, Bareber river, and other reference sites needs to be taken into consideration for the future assessments.
- On the other hand, Alareks river (#361), Marts river sampling site (MA) located above the village of Atan, Chr-chr waterfall (site Ag) reference site for Aghstev river have been classified as the sites having “Good” class and could be used as a reference site.
- Nevertheless, in the Debed river basin, the influence of the interstate road as a source of diffuse pollution is also not excluded. However, such an impact assessment has not yet been carried out in Armenia.

List of Attachments

Annex

Annex 1: Field protocols (See attached files)

Annex 2: Photo documentation (See attached files)

Annex 3: Hydromorphology (See attached files)

Annex 4: Chemical data summary (See attached files)

Annex 5: Protocol for sample delivery and handover (See attached files)

Annex 6: Biological data summary (See attached files)

Annex 7: Water quality norms (See attached files)

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