EU4Environment in Eastern Partner Countries: Water Resources and Environmental Data (ENI/2021/424-4550)

SURFACE WATER SURVEY IN THE NORTHERN WBMA 2022

ARMENIA

20940-C1/AM-HMC-2022/2

Draft Technical Report

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LIST OF ABBREVIATIONS

COD	Chemical oxygen demand
EC	European Commission
HMC	Hydrometeorology and Monitoring Center
EU	European Union
EUWI	European Union Water Initiative
HPP	Hydropower Plant
RBD	River Basin District
SNCO	State non-commercial organization
SW	Surface water

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-2022/2) the ecological survey was carried out in 25 sampling sites in Northern RBD of Armenia, which includes water sampling, chemical and biological analyses and the hydro-morphological description of the sampling sites.

1. INTRODUCTION AND SCOPE

The objective of the survey in summer 2022 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 data base for the upcoming risk, status and trend assessment

2. GENERAL DESCRIPTION OF THE SURVEY

2.1 Selected pilot river basins and sampling sites

The sampling was done in 25 sampling sites of the Northern Basin Management Area (WBMA). In general, 16 rivers of Debed and Aghstev RBD, and 2 small rivers of Kura River basin were investigated.

The list of sampling site and their description are given in Table 1 and presented in Figure 1. The detailed information on altitude, catchment area, geology and typology are given in the Annex 1 and 3.

Table 1. List of sampling sites in Norther WBMA

River Basin	River name	Site location	Site No.	Longitude	Latitude
Debed	Chichkan	Up to village Shirakamut	SW-359	40.52170	44.09192
	Garpi	1 km up to Vanadzor city	SW-GA	40.45093	44.32319
	Pambak	Mouth	SW-362	40.56442	44.37485
	Sevaberd	Up to village Noramut	SW-364	41.06294	44.08153
	Katnaghbyur	Up to village Urasar	SW-365	41.00489	44.17415
	Katnaghbyur	Village Armanis	SW-366	41.00385	44.21294
	Dzoraget	Mouth	SW-10	40.57283	44.37514
	Jukhtak	Up to village Marts	SW-367	40.55166	44.43373
	Martsiget	Mouth	SW-13	40.59076	44.39137
	Lalvar	Mouth	SW-368	41.05497	44.39319
	Debed	Down to Alaverdi city	SW-369	41.05449	44.40336
	Akhtala	Up to village Bendik	SW-371	41.09241	44.42078
	Akhtala	Mouth	SW-14	41.08573	44.46547
	Nahatak	Mouth	SW-373	41.09547	44.50148
	Debed	2.3 km after the spilling of the Nahatak river	SW-370	41.10418	44.51372
	Snogh	Up to village Teghut	SW-345	41.05482	44.52028
	Snogh	Mouth	SW-343	41.08374	44.49583
	Debed	Near the border	SW-7	41.13045	44.52114
Aghstev	Aghstev	0.5 km below Dilijan city	SW-16	40.45251	44.53229
	Aghstev	2 km below Ijevan city	SW-18	40.55243	45.09213
	Getik	0.5 km up to village Vahan	SW-19	40.34283	45.24285
	Getik	Mouth	SW-20	40.45525	45.01071
	Voskepar	Village Voskepar	SW-Vo	41.04183	45.04064
Small tributary of Kura River	Tavush	Down to Verin Karmir	SW-23	40.55027	45.26274
	Hakhum	Down to Varagavan	SW-24	40.57105	45.21421

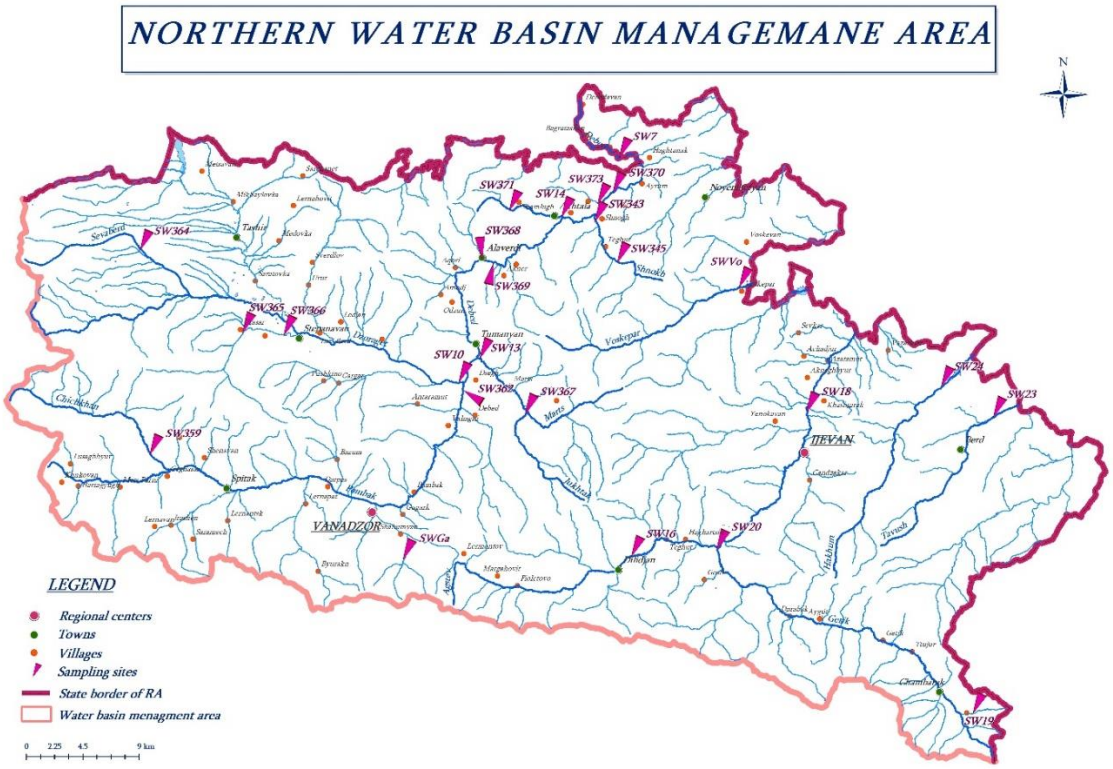

Figure 1. Map of Water Sampling Sites in the Norther RBD

2.2 Sampling period

The sampling was done from 22 to 30, August 2022. The dates and time of the transport of the field survey were coordinated with the experts responsible for the sampling. The detailed information on sampling dates is presented in Table 2.

Table 2 Sampling dates, information on meteorological and hydrological conditions

River Basin	***Date***	***Site No.***	***Meteorology***	***Hydrology***
Debed	*22.08.2022*	*SW-359*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Debed	*22.08.2022*	*SW-GA*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: middle Stream order: second Turbidity of water: no turbidity*
Debed	*23.08.2022*	*SW-362*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: middle Stream order: first Turbidity of water: no turbidity*
Debed	*22.08.2022*	*SW-364*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Debed	*23.08.2022*	*SW-365*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: middle Stream order: second Turbidity of water: no turbidity*
Debed	*23.08.2022*	*SW-366*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: middle Stream order: second Turbidity of water: no turbidity*
Debed	*23.08.2022*	*SW-10*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	River type: middle *Stream order: second Turbidity of water: no turbidity*
Debed	*23.08.2022*	*SW-367*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Debed	*23.08.2022*	*SW-13*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Debed	*24.08.2022*	*SW-368*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Debed	*24.08.2022*	*SW-369*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: large Stream order: first Turbidity of water: no turbidity*
Debed	*24.08.2022*	*SW-371*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Debed	*24.08.2022*	*SW-14*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*

River Basin	***Date***	***Site No.***	***Meteorology***	***Hydrology***
Debed	*24.08.2022*	*SW-373*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Debed	*25.08.2022*	*SW-370*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: middle Stream order: second Turbidity of water: no turbidity*
Debed	*25.08.2022*	*SW-345*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Debed	*25.08.2022*	*SW-343*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Debed	*25.08.2022*	*SW-7*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Calm;*	*River type: first Stream order: large Turbidity of water: no turbidity*
Aghstev	*29.08.2022*	*SW-16*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: middle Stream order: first Turbidity of water: no turbidity*
Aghstev	*29.08.2022*	*SW-18*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: middle Stream order: first Turbidity of water: no turbidity*
Aghstev	*30.08.2022*	*SW-19*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Aghstev	*30.08.2022*	*SW-20*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*
Aghstev	*26.08.2022*	*SW-Vo*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity:*
Small tributaries of Kura River	*26.08.2022*	*SW-23*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: first Turbidity of water: no turbidity*
Small tributaries of Kura River	*26.08.2022*	*SW-24*	*Light conditions: Sunny; Precipitation: Dry; Air temperature: Warm; Wind: Not available*	*River type: small Stream order: second Turbidity of water: no turbidity*

2.3 Responsibilities

For the proper work each part of the survey has its own responsible person. The contacts of the responsible persons are represented 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 body sampling	Institute: Hydrometeorology and Monitoring Center SNCO, Ministry of Environment 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,
Field work	
Responsible for field work (biological and chemical sampling, hydro-morphological site description, hydrological measurements)	Institute: Hydrometeorology and Monitoring Center SNCO, Ministry of Environment Contact person: 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, Ministry of Environment Chemical: Tigran Araqelyan, E-Mail: tigranarakelyan91@mail.ru Biological: Vardan Karyan, E-Mail: VHKaryan@gmail.com,
Responsible for calibration of on-site measuring equipment	Institute: Hydrometeorology and Monitoring Center SNCO, Ministry of Environment Tigran Araqelyan, E-Mail: tigranarakelyan91@mail.ru
Chemical analysis	
Overall responsible for the chemical analysis in the lab, including reporting and data delivery	Institute: Hydrometeorology and Monitoring Center SNCO, Ministry of Environment Contact person: Gayane Shahnazaryan (Deputy Director), E-Mail: shahnazaryangayane@gmail.com Alina Zurnachyan (Head of surface water quality monitoring service) E-Mail: alina.zurnachyan@gmail.com Anna Zatikyan (Head *of Information Analytical Service*) E-Mail: anna_zatikyan@hotmail.com
Responsible for sample transport from the field to the laboratory	Institute: Hydrometeorology and Monitoring Center SNCO, Ministry of Environment Contact person: Tigran Araqelyan (Head of surface water quality field survey and sampling department) E-Mail: tigranarakelyan91@mail.ru
Analyzing laboratory and contact person	Institute: Hydrometeorology and Monitoring Center SNCO, Ministry of Environment

	Contact person: Alina Zurnachyan (Head of surface water quality monitoring service) E-Mail: alina.zurnachyan@gmail.com
Biological analysis	
Overall responsible for the biological analysis in the lab, including reporting and data delivery	Institute: Hydrometeorology and Monitoring Center SNCO, Ministry of Environment Contact person: Vardan Karyan (Head of soil, sediment and hydrobiological monitoring service) E-Mail: VHKaryan@gmail.com Hayk Minasyan, E-Mail: h.s.minasyanc@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

Parameter	**Unit**
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
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 done by field team (presented in Table 2). The water sampling was conducted following the requirements of ISO 5667-3:2018 and General Manual for Surveys in Running Waters (EUWI+, ENI/2016/372-403). Water samples for chemical analysis have been taken with containers are made in HD PE. The sampling containers (as well as the filtration units and the preservation substances, if necessary) were provided by the laboratory and was labelled clearly attributable to the sampling site and river.

The taking of the water samples for the chemical analyses was done before taking biological samples to avoid bias effects from stirred-up sediment. During the sampling, care has been taken about possible disturbing effects from upstream, which may cause an enhanced turbidity. Before the sampling bottle is filled, it is rinsed with sample water. The sample was generally taken directly by hand. Most representative samples are collected at mid-height between surface and bottom.

All bottles were put into cooling boxes immediately after the sampling. Transportation of water samples was carried out according to the sampling programme *(ISO 5667-1:2018; ISO 5667-3:2018).*

The surface water samples were transported to HMC laboratory for the further processing and analysis. The handover was documented by 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

13 general physico-chemical parameters and 22 heavy metals have been analyzed in each of the 25 water samples. 5 parameters (Water temperature, Oxygen concentration, Oxygen Saturation, Electric conductivity and pH) have been measured in the field by the sampling team

(see Table 3). 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 5814:2012
Oxygen saturation (O_2-Sat)	%			ISO 10523:
pH	-			ISO 10523:2008
Electric conductivity (EC)	µS/cm			ISO 7888:1985
Laboratory analyses				
Water temperature (WT, lab control)	°C			
Oxygen concentration (DO, lab control)	mg/L			ISO 5814:2012
Oxygen saturation (O_2-Sat, lab control)	%			ISO 5814:2012
pH (lab control)	-			ISO 10523:2008
Electric conductivity (EC, lab control)	µS/cm			ISO 7888:1985
Total suspended solids (TSS)	mg/L			ISO 11923:1997
Biological oxygen demand (BOD_5)	mg/L			ISO 5815:2003
Chemical oxygen demand ($K_2Cr_2O_7$) (COD)	mg/L			ISO 6060:1989
Ammonia-N (NH_4-N)	mg/L	0.003	0.005	ISO 7150-1:1984
Nitrate-N (NO_3-N)	mg/L	0.001	0.01	ISO 10304-1:2007
Nitrite-N (NO_2-N)	mg/L	0.001	0.002	ISO 6777-2015
Orthophosphate, as P (PO_4-P)	mg/L	0.001	0.002	ISO 6878:2004
Total phosphorus (TP)	mg/L	0.005	0.01	ISO 17294:2016
Chloride (Cl)	mg/L	0.025	0.05	ISO 10304-1:2007
Sulphate, total ion (SO_4)	mg/L	0.125	0.25	ISO 10304-1:2007
Calcium (Ca)	mg/L	0.005	0.01	ISO 17294:2016
Magnesium (Mg)	mg/L	0.005	0.01	ISO 17294:2016
Sodium (Na)	mg/L	0.005	0.01	ISO 17294:2016
Potassium (K)	mg/L	0.005	0.01	ISO 17294:2016
Lithium (Li)	mg/L	0.00005	0.0001	ISO 17294:2016
Beryllium (Be)	mg/L	0.00005	0.0001	ISO 17294:2016
Boron (B)	mg/L	0.0005	0.001	ISO 17294:2016
Aluminum (Al)	mg/L	0.005	0.01	ISO 17294:2016
Titanium (Ti)	mg/L	0.00005	0.0001	ISO 17294:2016

Parameter	Unit	LOD	LOQ	Standards
Vanadium (V)	mg/L	0.00005	0.0001	ISO 17294:2016
Chromium (Cr)	mg/L	0.00005	0.0001	ISO 17294:2016
Iron (Fe)	mg/L	0.005	0.01	ISO 17294:2016
Manganese (Mn)	mg/L	0.00005	0.0001	ISO 17294:2016
Cobalt (Co)	mg/L	0.00005	0.0001	ISO 17294:2016
Nickel (Ni)	mg/L	0.00005	0.0001	ISO 17294:2016
Copper (Cu)	mg/L	0.00005	0.0001	ISO 17294:2016
Zink (Zn)	mg/L	0.00005	0.0001	ISO 17294:2016
Arsenic (As)	mg/L	0.00005	0.0001	ISO 17294:2016
Selenium (Se)	mg/L	0.00005	0.0001	ISO 17294:2016
Strontium (Sr)	mg/L	0.00005	0.0001	ISO 17294:2016
Molybdenum (Mo)	mg/L	0.00005	0.0001	ISO 17294:2016
Cadmium (Cd)	mg/L	0.00005	0.0001	ISO 17294:2016
Tin (Sn)	mg/L	0.0005	0.001	ISO 17294:2016
Stibium (Sb)	mg/L	0.00005	0.0001	ISO 17294:2016
Barium (Ba)	mg/L	0.005	0.01	ISO 17294:2016
Lead (Pb)	mg/L	0.00005	0.0001	ISO 17294:2016

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

All specimens were picked out of the sediment sample were kept for later validation and stored 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 evaluated results are summarized in **Fehler! Verweisquelle konnte nicht gefunden werden.**7. 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 (ield guide for freshwater invertebrates, Kaliningrad 2002)
- Süßwassermollusken, Peter Glöer, 2017
- Lauterbornia volume 66, A guide to the freshwater oligochaeta and polychaeta of Northern and Central Europe, Tarmo Timm, 2009
- Hydrobiologicky Determinacny Atlas (Hydrobiological Determination Atlas), Emilia Elexova, Bratislava 2000
- Plecoptera Slovenska (Plecoptera of Slovakia), I. Krno, Bratislava 2011
- Podenky (Ephemeroptera), I. Krno, T. Derka, Bratislava 2011
- Key to Families of Macroinvertebrates in European Freshwaters, Lechthaler Wolfgang, Austria 2009
- Website: https://www.macroinvertebrates.org/

3.3 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

4.1 Field protocols

The sampling team has 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 Chemical analyses

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	*River*	*Site No.*	*Water quality parameters*	*Water quality class*	*Water quality based on chemical parameters*
Debed	*Chichkhan*	*SW-359*	*-*	*Good*	*Good*
	Garpi	*SW-Ga*	*Mo*	*Moderate*	*Moderate*
	Pambak	*SW-362*	*NO_3, PO_4, Mo, TIN, TP, TDS, SS*	*Moderate*	*Poor*
			NO_2	*Poor*	
	Sevaberd	*SW-364*	*-*	*Good*	*Good*
	Katnaxbyur	*SW-365*	*-*	*Good*	*Good*
	Katnaxbyur	*SW-366*	*Fe, Al*	*Moderate*	*Bad*
			Co	*Poor*	
			Zn, Cd, Mn	*Bad*	
	Dzoraget	*SW-10*	*-*	*Good*	*Good*
	Jukhtak	*SW-367*	*-*	*Good*	*Good*
	Martsiget	*SW-13*	*-*	*Good*	*Good*

RBD	River	Site No.	Water quality parameters	Water quality class	Water quality based on chemical parameters
	Lalvar	*SW-368*	*NH_4, Cu, Mo, Mg, TDS, SS*	*Moderate*	*Bad*
			Co, Fe, Ca	*Poor*	
			Sulphate	*Bad*	
	Debed	*SW-369*	*NO_2*	*Moderate*	*Moderate*
	Akhtala	*SW-371*	*Ca, TDS*	*Moderate*	*Moderate*
	Akhtala	*SW-14*	*Ni, Mg, Sb, TIN, TDS*	*Moderate*	*Bad*
			NH_4, Cu, Fe, Ca	*Poor*	
			NO_2, Zn, Cd, Mo, Mn, Co, sulphate, SS	*Bad*	
	Nahatak	*SW-373*	*Na, Sb*	*Moderate*	*Bad*
			NO_3, Fe, Ca, TIN, TDS	*Poor*	
			NH_4, NO_2, Mo, sulphate	*Bad*	
	Debed	*SW-370*	*NO_3, Na, sulphate, TDS*	*Moderate*	*Bad*
			Mo	*Bad*	
	Shnogh	*SW-345*	*TDS*	*Moderate*	*Bad*
			Mo	*Bad*	
	Shnogh	*SW-343*	*NO_3, Fe, Ca, TDS*	*Moderate*	*Bad*
			Mo, sulphate	*Bad*	
	Debed	*SW-7*	*NO_3, Cu, Na, sulphate, TDS, SS*	*Moderate*	*Bad*
			Mo	*Bad*	
Aghstev	*Voskepar*	*SW-Vo*	*NH_4, TDS*	*Moderate*	*Moderate*
	Getik	*SW-19*	*NH_4, SS*	*Moderate*	*Moderate*
	Getik	*SW-20*	*NH_4,*	*Moderate*	*Moderate*
	Aghstev	*SW-16*	*PO_4*	*Moderate*	*Poor*
			NO_2, Mo	*Poor*	
	Aghstev	*SW-18*	*NH_4, PO_4, Mo, TDS*	*Moderate*	*Poor*
			NO_2	*Poor*	
Small tributaries of Kura River	*Tavush*	*SW-23*	*NH_4, Mo, sulphate, TDS, SS*	*Moderate*	*Moderate*
	Hakhum	*SW-24*	*NH_4, NO_3, Mo, TIN*	*Moderate*	*Bad*
			Fe, Ca, B, TDS	*Poor*	
			Na, sulphate	*Bad*	

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.

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).

Table 7. Ecological Status at the sampling sites

River	Site No.	Type of sampling site	Nr. of taxa	Total abundance [m²]	nEQR	Ecological status
Chichkhan	SW-359	R	21	162	0.90	High
Garpi	SW-Ga	R	20	182	1.00	High
Pambak	SW-362	I	7	115	0.00	Bad
Sevaberd	SW-364	R	18	1086	1.00	High
Katnaxbyur	SW-365	R	25	626	1.00	High
Katnaxbyur	SW-366	I	0	0	0.00	Bad
Dzoraget	SW-10	I	18	551	0.76	Good
Jukhtak	SW-367	R	22	487	1.00	High
Martsiget	SW-13	I	15	223	1.00	High
Lalvar	SW-368	I	0	0	0.00	Bad
Debed	SW-369	I	11	824	0.70	Good
Akhtala	SW-371	R	20	686	1.00	High
Akhtala	SW-14	I	0	0	0.00	Bad
Nahatak	SW-373	I	0	0	0.00	Bad
Debed	SW-370	I	6	114	0.56	Moderate
Shnogh	SW-345	R	21	162	0.90	High
Shnogh	SW-343	I	4	150	0.00	Bad
Debed	SW-7	I	1	2	0.05	Bad
Voskepar	SW-Vo	I	16	337	0.95	High
Getik	SW-19	R	18	514	0.43	Moderate
Getik	SW-20	I	17	254	0.69	Good
Aghstev	SW-16	I	11	138	0.28	Poor
Aghstev	SW-18	I	7	530	0.40	Poor
Tavush	SW-23	I	27	661	0.70	Good
Hakhum	SW-24	I	18	443	1.00	High

(R=reference, I=influenced)

In rivers of Katnaghbyur (SW-366), Lalvar (SW-368), Akhtala (SW-14) and Nahatak (SW373) no animals were found.

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 name	Date	Survey unit No	Site name	Hydrological status	Morphological status	Hy-Mo Status
Debed	25/08/22	SW-7	Near the border	2.5	1.3	1.90
Dzoraget	23/08/22	SW-10	Mouth	1.0	1.7	1.35
Martsiget	23/08/22	SW-13	Mouth	1.0	2.0	1.50
Akhtala	24/08/22	SW-14	Mouth	1.0	2.0	1.50
Aghstev	29/08/22	SW-16	0.5 km below Dilijan city	2.5	2.7	2.60
Aghstev	29/08/22	SW-18	2 km below Ijevan city	2.0	1.5	1.75
Getik	30/08/22	SW-19	0.5 km up to village Vahan	1.0	1.4	1.20
Getik	30/08/22	SW-20	Mouth	2.0	1.8	1.90
Tavush	26/08/22	SW-23	Near the border	1.0	1.7	1.35
Hakhum	26/08/22	SW-24	Near the border	1.0	1.3	1.15
Shnogh	25/08/22	SW-343	Mouth	1.0	1.7	1.35
Shnogh	25/08/22	SW-345	Up to village Teghut	1.0	1.3	1.15
Chichkhan	22/08/22	SW-359	Up to village Shirakamut	2.5	1.8	2.15
Pambak	23/08/22	SW-362	Mouth	2.5	1.7	2.10
Sevaberd	22/08/22	SW-364	Up to village Noramut	1.5	1.6	1.55
Katnagh-byur	23/08/22	SW-365	Up to village Urasar	2.5	1.4	1.95
Katnagh-byur	23/08/22	SW-366	Village Armanis	3.0	1.4	2.20
Jukhtak	23/08/22	SW-367	Up to village Marts	1.0	1.4	1.20
Lalvar	24/08/22	SW-368	Mouth	1.0	2.6	1.80
Debed	24/08/22	SW-369	Down to Alaverdi city	3.0	1.8	2.40
Debed	25/08/22	SW-370	2.3 km after the spilling of the Nahatak river	1.0	1.5	1.25
Aghtala	24/08/22	SW-371	Up to village Bendik	1.0	1.3	1.15
Nahatak	24/08/22	SW-373	Mouth	2.0	1.3	1.65
Garpi	22/08/22	SW-Ga	1 km up to Vanadzor city	1.0	1.3	1.15
Voskepar	26/08/22	SW-Vo	Village Voskepar	2.5	2.3	2.40

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	Date	Survey unit No	Mean flow	Low flow	Water level range	Flow fluctuation	Hydro Score
Debed	25/08/22	SW-7	3	3	1	3	2.5
Dzoraget	23/08/22	SW-10	1	1	1	1	1.0
Martsiget	23/08/22	SW-13	1	1	1	1	1.0
Akhtala	24/08/22	SW-14	1	1	1	1	1.0
Aghstev	29/08/22	SW-16	3	3	1	3	2.5
Aghstev	29/08/22	SW-18	3	3	1	1	2.0
Getik	30/08/22	SW-19	1	1	1	1	1.0
Getik	30/08/22	SW-20	3	3	1	1	2.0
Tavush	26/08/22	SW-23	1	1	1	1	1.0
Hakhum	26/08/22	SW-24	1	1	1	1	1.0
Shnogh	25/08/22	SW-343	1	1	1	1	1.0
Shnogh	25/08/22	SW-345	1	1	1	1	1.0
Chichkhan	22/08/22	SW-359	3	3	3	1	2.5
Pambak	23/08/22	SW-362	3	3	3	1	2.5
Sevaberd	22/08/22	SW-364	1	1	3	1	1.5
Katnaghbyur	23/08/22	SW-365	3	3	3	1	2.5
Katnaghbyur	23/08/22	SW-366	3	3	5	1	3.0
Jukhtak	23/08/22	SW-367	1	1	1	1	1.0
Lalvar	24/08/22	SW-368	1	1	1	1	1.0
Debed	24/08/22	SW-369	3	3	3	3	3.0
Debed	25/08/22	SW-370	1	1	1	1	1.0
Aghtala	24/08/22	SW-371	1	1	1	1	1.0
Nahatak	24/08/22	SW-373	3	3	1	1	2.0
Garpi	22/08/22	SW-Ga	1	1	1	1	1.0
Voskepar	26/08/22	SW-Vo	3	3	3	1	2.5

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	Date	Survey unit No	Channel form	Instream features	Riparian zone	Floodplain	Morph Score
Debed	25/08/22	SW-7	1.0	2.0	1.3	1.0	1.3
Dzoraget	23/08/22	SW-10	1.0	2.2	1.6	2.0	1.7
Martsiget	23/08/22	SW-13	1.0	2.4	2.7	2.0	2.0
Akhtala	24/08/22	SW-14	1.0	2.6	2.3	2.0	2.0
Aghstev	29/08/22	SW-16	1.0	2.7	4.0	3.0	2.7
Aghstev	29/08/22	SW-18	1.0	2.1	2.0	1.0	1.5
Getik	30/08/22	SW-19	1.0	2.6	1.0	1.0	1.4
Getik	30/08/22	SW-20	1.0	2.1	3.0	1.0	1.8
Tavush	26/08/22	SW-23	1.0	2.4	2.3	1.0	1.7

River basin/River name	Date	Survey unit No	Channel form	Instream features	Riparian zone	Floodplain	Morph Score
Hakhum	26/08/22	SW-24	1.0	2.3	1.0	1.0	1.3
Shnogh	25/08/22	SW-343	1.0	2.7	2.0	1.0	1.7
Shnogh	25/08/22	SW-345	1.0	2.3	1.0	1.0	1.3
Chichkhan	22/08/22	SW-359	1.0	3.2	1.7	1.5	1.9
Pambak	23/08/22	SW-362	1.7	2.1	1.7	1.5	1.8
Sevaberd	22/08/22	SW-364	1.0	2.3	1.1	2.1	1.6
Katnagh-byur	23/08/22	SW-365	1.0	2.2	1.0	1.5	1.4
Katnagh-byur	23/08/22	SW-366	1.0	2.1	1.0	1.5	1.4
Jukhtak	23/08/22	SW-367	1.0	2.4	1.0	1.0	1.4
Lalvar	24/08/22	SW-368	1.0	2.5	5.0	2.0	2.6
Debed	24/08/22	SW-369	1.0	2.1	2.0	2.0	1.8
Debed	25/08/22	SW-370	1.0	1.8	1.7	1.5	1.5
Aghtala	24/08/22	SW-371	1.0	2.2	1	1.0	1.3
Nahatak	24/08/22	SW-373	1.0	2.2	1	1.0	1.3
Garpi	22/08/22	SW-Ga	1.0	2.2	1	1.0	1.3
Voskepar	26/08/22	SW-Vo	1.0	2.9	3.3	2.0	2.3

5. DISCUSSION OF RESULTS

5.1 Water quality assessment

Water quality based on chemical parameters is “bad” in 9 sampling sites at 7 rivers. In 3 sampling sites, the water quality is “poor”, in 7 sampling sites-“moderate”, and “good”-in 6 sampling sites.

Basically, the classes of water quality based on biological and chemical parameters are different. Only, in 10 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 physico-chemical parameters.
At the sampling site SW-345 “bad” water quality was formed due to the only one chemical parameter Mo.

When considering only parameters required for the assessment of the ecological status according to the WFD (Oxygenation conditions: DO and BOD_5, Salinity: chloride, Acidification status: pH, Nutrient conditions: NO_3-N, PO_4, TP; Specific pollutants: NH_4-N and NO_2-N), the overall assessment is better. This is shown in the following table in a separate column.

Table 11. Ecological Status at the sampling sites

River	Site No.	*Type of sampling site*	Ecological status	Water quality based on chemical parameters	General physico-chemical parameters + specific pollutants	Hydromorpho-logical Status
Chichkhan	SW-359	*R*	High	Good	Good	Good
Garpi	SW-Ga	*R*	High	Moderate	High	High
Pambak	SW-362	*I*	Bad	Poor	Poor	Good
Sevaberd	SW-364	*R*	High	Good	Good	High
Katnaxbyur	SW-365	*R*	High	Good	Good	Good
Katnaxbyur	SW-366	*I*	Bad	Bad	Good	Good
Dzoraget	SW-10	*I*	Good	Good	Good	High
Jukhtak	SW-367	*R*	High	Good	High	High
Martsiget	SW-13	*I*	High	Good	Good	High
Lalvar	SW-368	*I*	Bad	Bad	Moderate	Good
Debed	SW-369	*I*	Good	Moderate	Moderate	Good
Akhtala	SW-371	*R*	High	Moderate	Good	High
Akhtala	SW-14	*I*	Bad	Bad	Bad	High
Nahatak	SW-373	*I*	Bad	Bad	Bad	High
Debed	SW-370	*I*	Moderate	Bad	Moderate	High

Shnogh	SW-345	*R*	High	Bad	Good	High
Shnogh	SW-343	*I*	Bad	Bad	Moderate	High
Debed	SW-7	*I*	Bad	Bad	Moderate	Good
Voskepar	SW-Vo	*I*	High	Moderate	Poor	Good
Getik	SW-19	*R*	Moderate	Moderate	Poor	High
Getik	SW-20	*I*	Good	Moderate	Moderate	Good
Aghstev	SW-16	*I*	Poor	Poor	Moderate	Moderate
Aghstev	SW-18	*I*	Poor	Poor	Moderate	Good
Tavush	SW-23	*I*	Good	Moderate	Moderate	High
Hakhum	SW-24	*I*	High	Bad	Moderate	High

(R=reference, I=influenced)

5.2 Analysis of trend in concentrations of water quality parameters

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 7.84 to 8.79.

Nutrients

The highest concentration of ammonium ion (Figure 2) was found in the rivers of Nahatak (SW-373) and Akhtala (SW-14) ranked as “bad” and “poor” classes, respectively. In the rivers of Lalvar (SW-368), Voskepar (SW-Vo), Tavush (SW-23), Hakhum (SW-24), Getik (SW-19 and SW-20) and Aghstev (SW-18), the concentration of ammonia was assessed as “moderate”. In the remained sampling sites, the concentration of ammonia was assessed as "excellent” or good" classes.

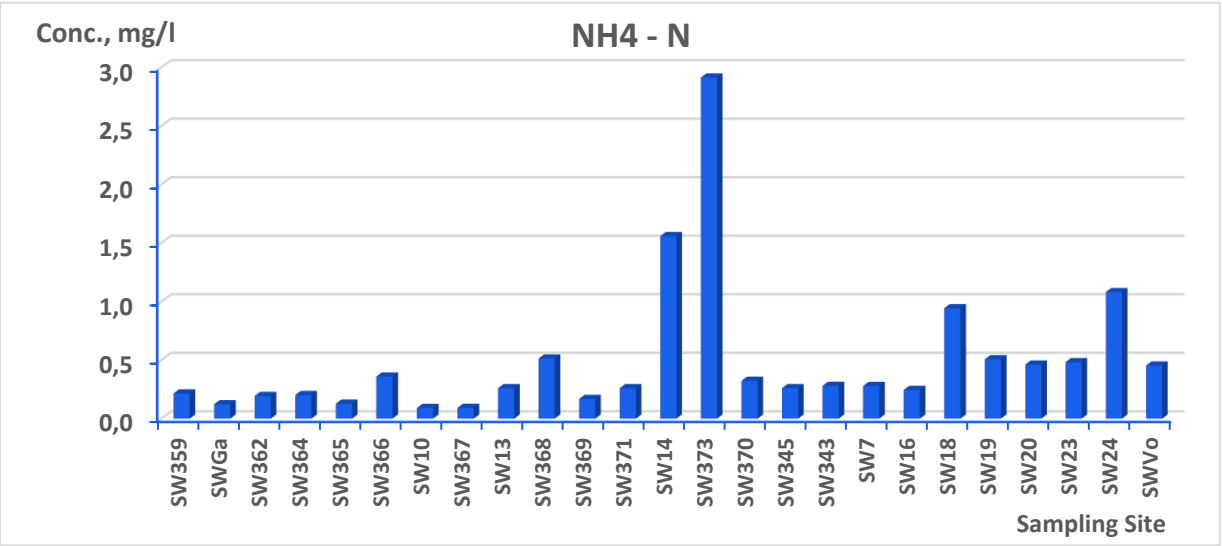

Figure 2. Ammonium ion concentration pattern in Northern WBMA

The concentration of nitrate ion (Figure 3), was relatively high in the Nahatak river (SW-373) rated "poor" class. In the rivers of Pambak (SW-362), Debed (SW-7 and SW-370), Shnogh (SW-343) and Hakhum (SW-24), the concentration of nitrate ion was assessed as “moderate”. In the remained sampling sites, the concentration of nitrate ion was assessed as "excellent” or “good" classes.

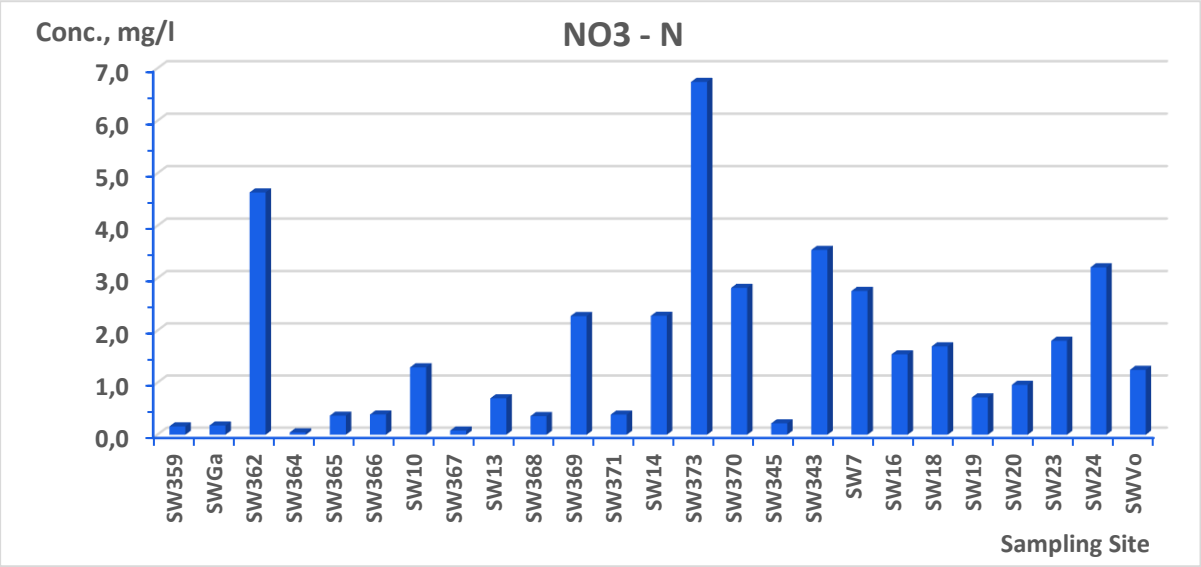

Figure 3. Nitrate ion concentration pattern in Northern WBMA

The highest concentration of nitrite ion (Figure 4) was found in the rivers of Akhtala (SW-14), Nahatak (SW-373), Pambak (SW-362), and Aghstev (SW-16 and SW-18) ranked as “bad” and “poor” classes.

In the Debed river (SW-369) the concentration of nitrite was assessed as “moderate”. In the remained sampling sites, the concentration of nitrite was assessed as "excellent” or good" classes.

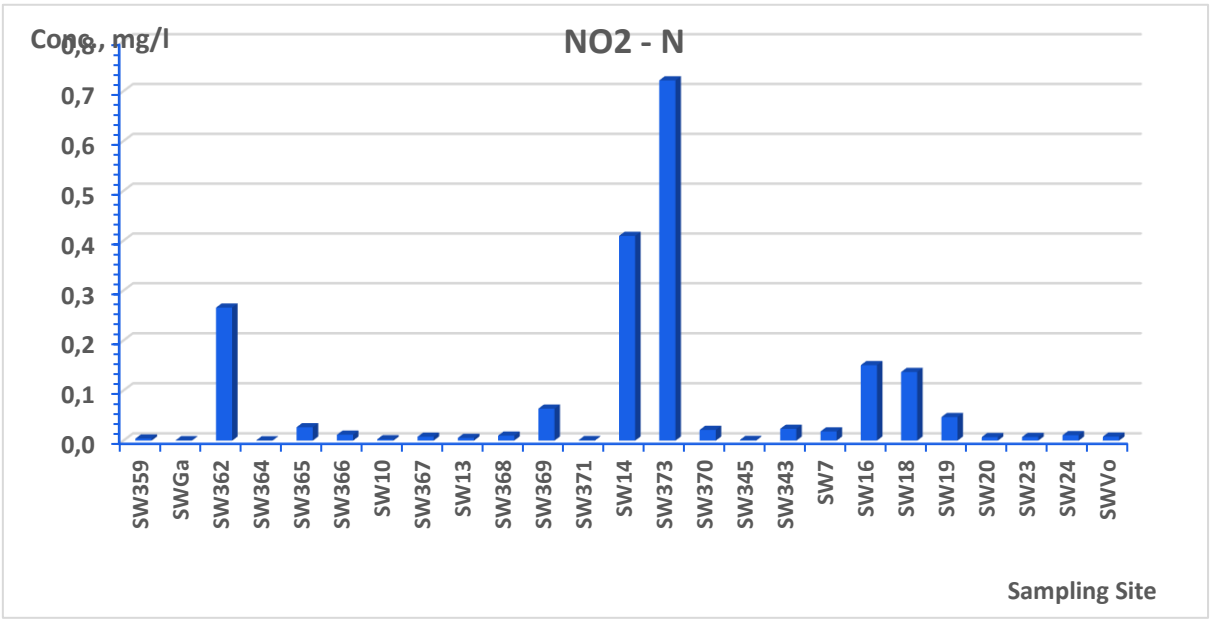

Figure 4. Nitrite ion concentration pattern in Northern WBMA

The concentration of phosphate ion (Figure 5) were rated "excellent or good" in all observation points, only in the Rivers of Pambak (SW-362) and Aghstev (SW-16 and SW-18), was assessed as “moderate”.

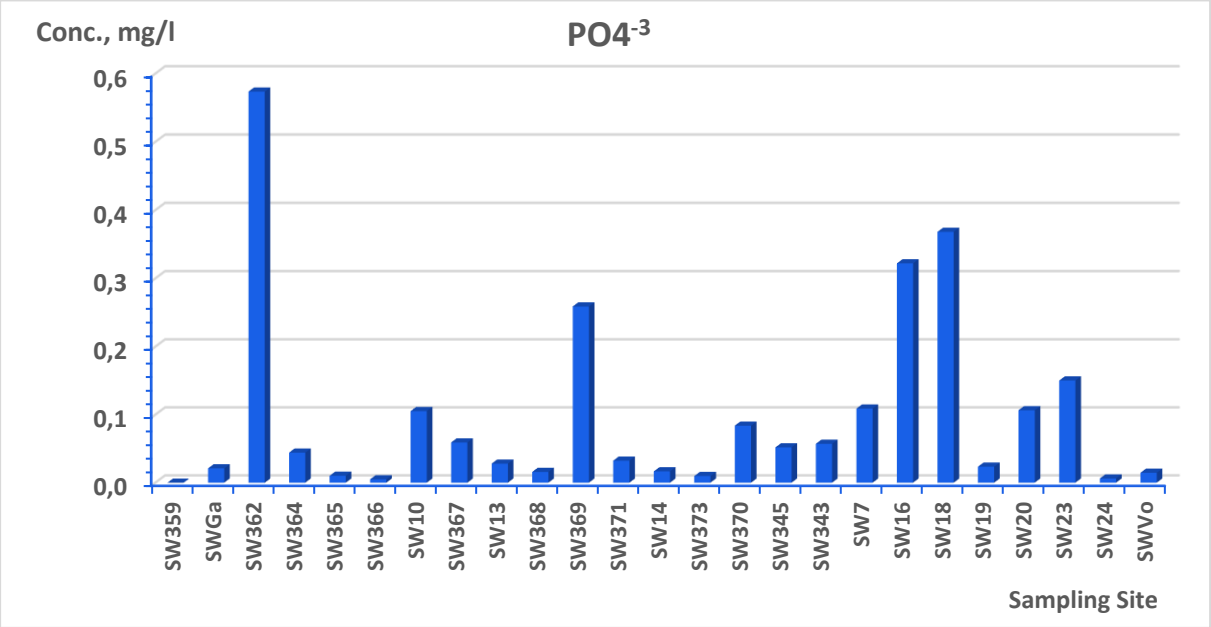

Figure 5. Phosphate ion concentration pattern in Northern WBMA

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 Lalvar (SW-368), Debed (SW-362, SW-370, and SW-7), Akhtala (SW-14 and SW-371), Shnogh (SW-343 and SW-345), Aghstev (SW-18), Voskepar (SW-Vo) and Tavush (SW-23). In the rivers of Nahatak (SW-373) and Hakhum (SW-24) the EC/TDS was ranked in “poor” class. In all other observation points were "excellent or good" (class 1 or 2).

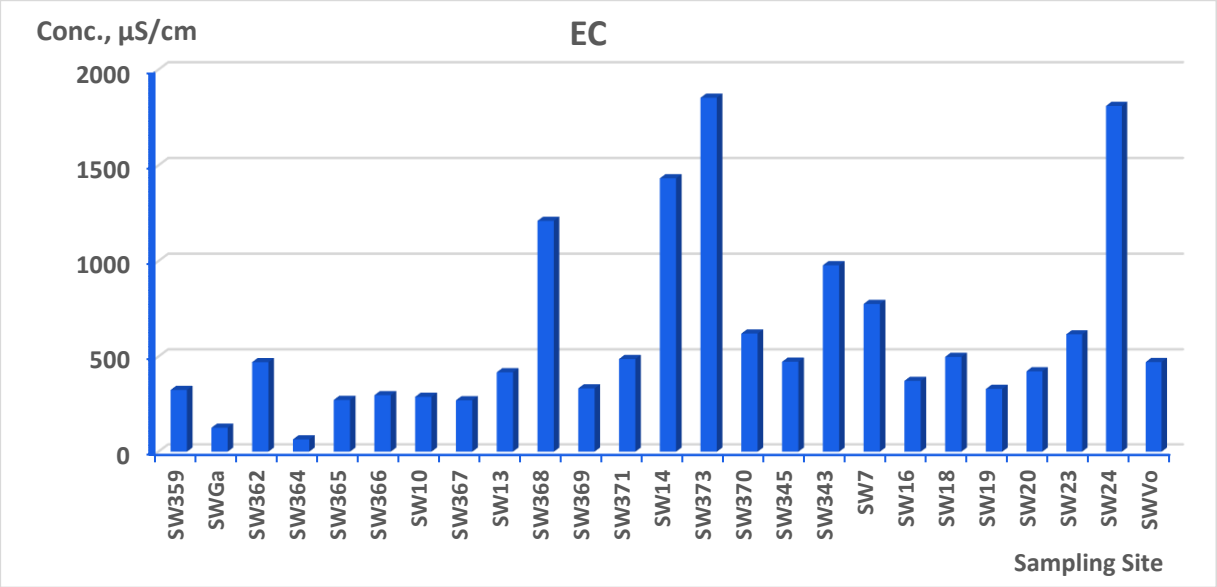

Figure 6. EC concentration pattern in Northern WBMA

Sulphate ion concentrations were rated "bad" (class 5) in the rivers of Lalvar (SW-368), Akhtala (SW-14), Nahatak (SW-373), Shnogh (343), and Hakhum (SW-24).

The "moderate" (class 3) in the river of Debed (SW-370 and SW-7) and Tavush (SW-23). In all other observation points were "excellent or good" (class 1 or 2).

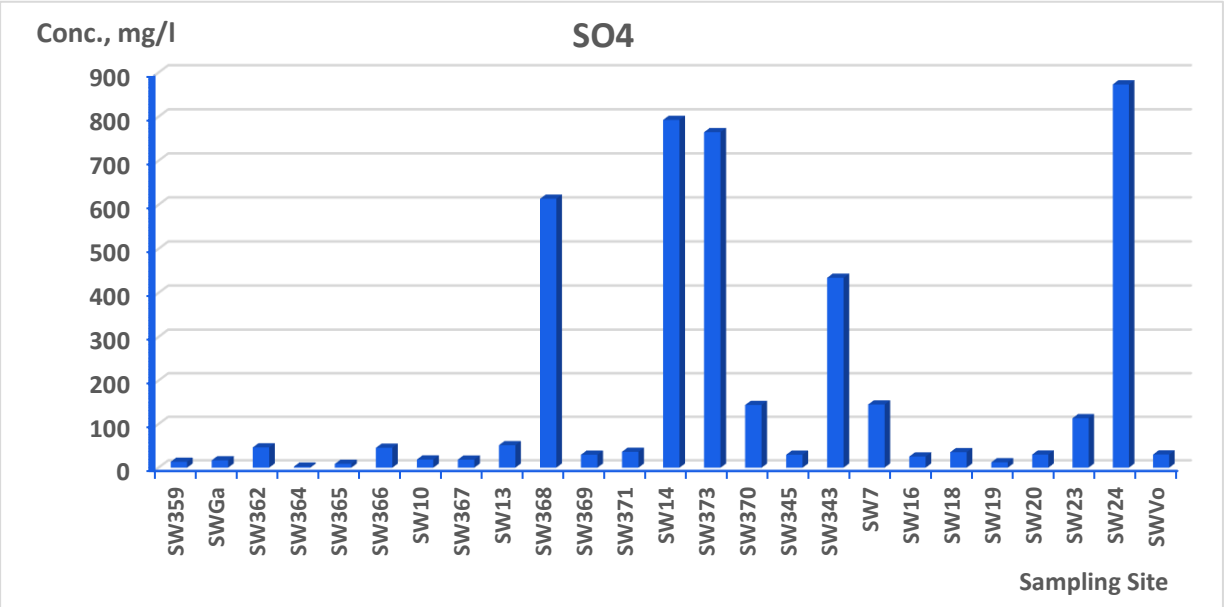

Figure 7. Sulphate ion concentration pattern in Northern WBMA

Heavy metals:

Water quality due to molybdenum concentration were rated (Figure 8) "moderate" (class 3) in the rivers of Debed (SW-362, and SW-7), Lalvar (SW-368) and Garpi (SW-Ga), "bad" (class 5) in the river mouths of Akhtala, Nahatak, Shnogh (up to village Teghut and mouth) and Debed river (2.3 km after the spilling of the Nahatak river and near the border).

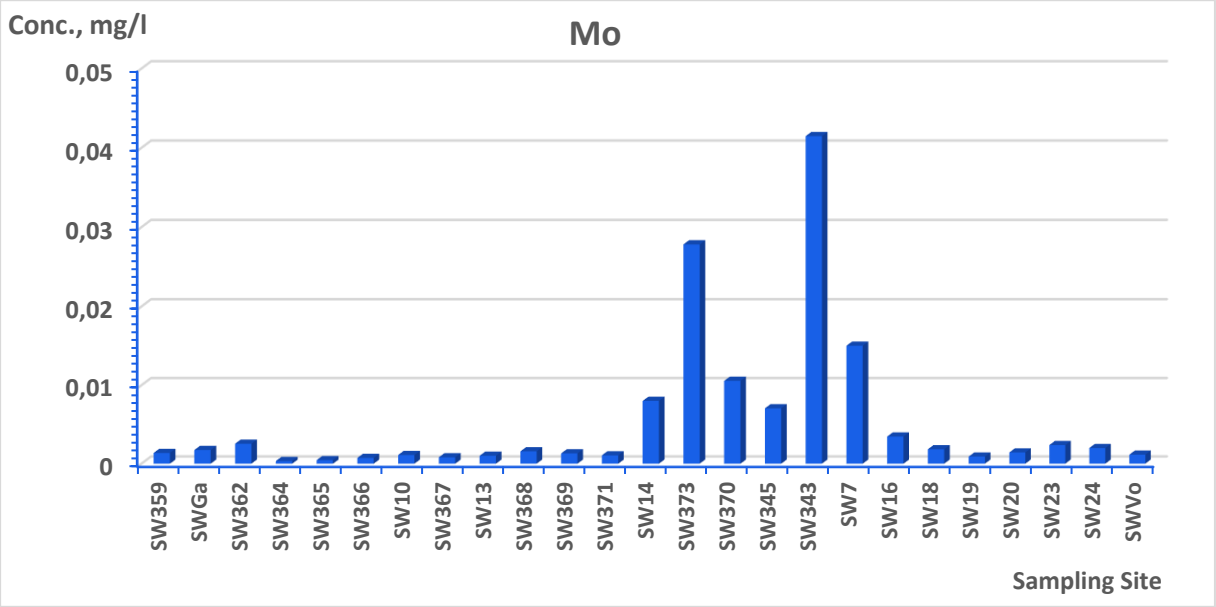

Figure 8. Mo concentration pattern in Northern WBMA

Cu concentrations (Figure 9) were rated “moderate” in the rivers of Lalvar (SW-368) and Debed (SW-7); and “poor” in the River of Akhtala (SW-14)

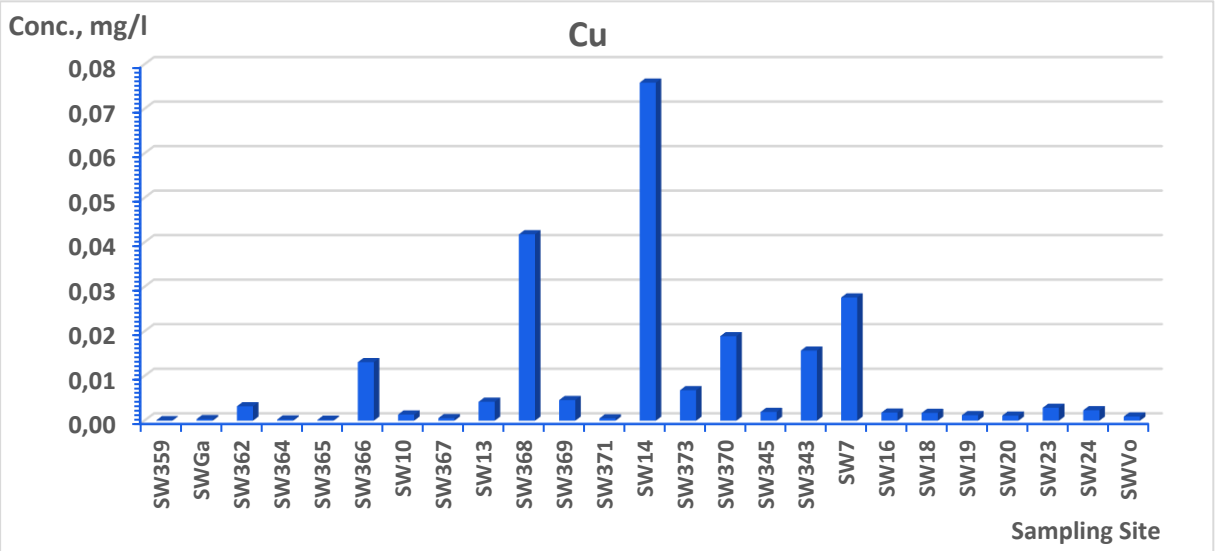

Figure 9. Cu concentration pattern in Northern WBMA

Zn and Cd concentrations were higher (10 and 11) in the rivers of Katnaghbyur (SW-366) and Akhtala (SW-14), where water quality was classified "bad" (class 5). in all other observation points were "excellent or good" (class 1 or 2). The influence of two mines, Armanis and Akhtala, is evident.

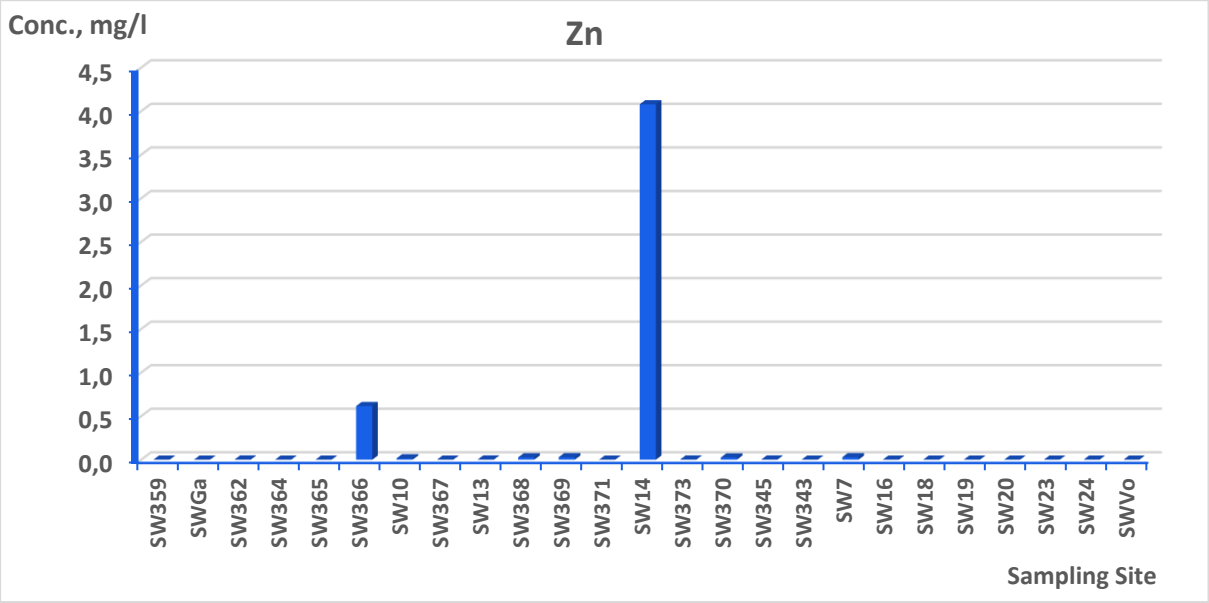

Figure 10. Zn concentration pattern in Northern WBMA

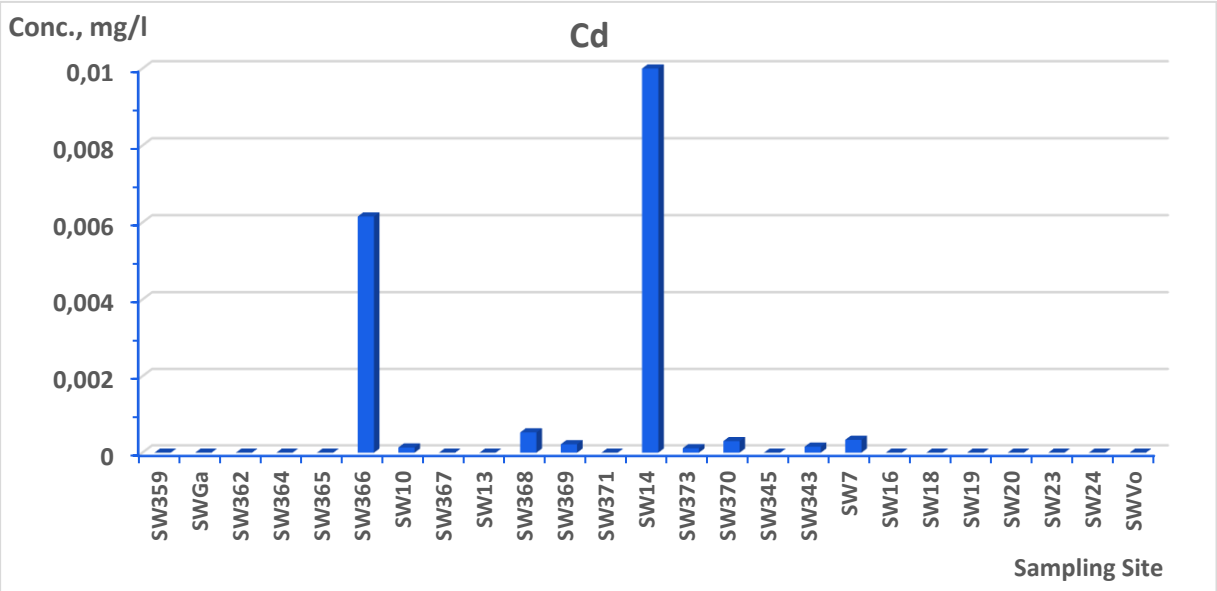

Figure 11. Cd concentration pattern in Northern WBMA

Water quality due to iron concentration was classified as "poor" in the rivers of Akhtala (SW-14), Lalvar (SW-368), Nahatak (SW-373) and Hakhum (SW-24); "moderate" in the rivers of Katnaghbyur (SW-366) and Shnogh (SW-343).

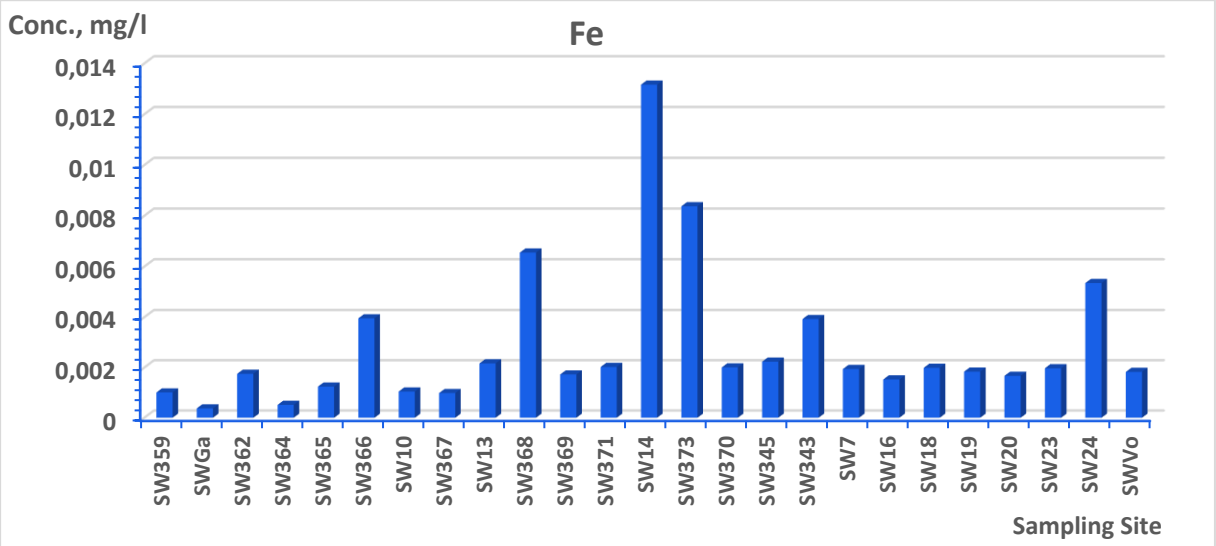

Figure 12. Fe concentration pattern in Northern WBMA

6. CONCLUSIONS AND LESSONS LEARNED

- During the sampling campaign in August 2022, it was possible to implement biological analysis in Debed RBD, to form a sound methodological basis for future monitoring programs as essential part of river basin management planning, to provide data for the assessment of the Debed and Aghstev RBDs as well as for the pressure-impact assessment in order to evaluate existing assessment methods or develop new ones, and to create a data base for the upcoming risk, status and trend assessment.
- Data from hydrobiological surveys generally matched expectations. In all reference sampling points, except the source of the Getik River above Vahan village, high ecological status was recorded. A moderate ecological status was recorded at the source of the Getik River. This may be due to the low discharge of the river and erosion from black soil in the catchment area. High ecological statuses were also registered in the Martsiget river near the mouth, which is affected by several small hydropower plants, and at the sampling sites of the Voskepar and Hakhum rivers, which are located on the border. In total, High ecological status was registered at 10 sampling sites.
- Good ecological status was recorded at 4 sampling sites: Dzoraget estuary, Debed below Alaverdi, Getik estuary, and Tavush below the reservoir. The situation at the Debed sampling site below the Alaverdi was unexpected and positive. In the city of Alaverdi, there are both communal-domestic pressures and pressures caused by mining activity on the Debed River. Therefore, the fact that the ecological status recorded there was better than during the monitoring carried out in previous years was surprising. The good ecological status reflects an encouraging positive trend.
- In addition, except for the source of the Getik River, the moderate ecological status was registered in the sampling site of the Qarkop settlement of the Debed River. There is quite a lot of mining pressure here, especially through the Nahatak River, which is under the direct influence of the tailings of the Akhtala Mining Complex. In total, Moderate ecological statuses were registered in 2 sampling sites.
- Poor ecological status was recorded at 2 sampling sites located after the cities of Dilijan and Ijevan on the Aghstev River. The pressures here are of a communal-domestic nature, but the influence of the interstate road as a source of diffuse pollution is not excluded.
- Bad ecological statuses were recorded in the 7 sampling points, which are located exclusively in the Debed river basin.
- The recorded bad ecological status in the estuarial sampling site of the Pambak river is entirely the result of the communal-domestic influence. Still, the influence of the interstate road as a source of diffuse pollution is not excluded either. The impacts of mining on the Pambak River have been assessed as part of research monitoring carried out this year. In particular, the effects of the Qaraberd gold mine and Hanqadzor abandoned/ownerless mining sites through Qaraberd and Sisi rivers were investigated. According to the research monitoring results, none of those mentioned above rivers has a significant negative impact on the Pambak River.
- The estuaries of Katnaghbyur, Lalvar, Akhtala, Nahatak, and Shnogh rivers are under the influence of various mining activities, which is the reason for the bad ecological status recorded in these sampling sites. A bad ecological status was also recorded at the border

sampling site of the Debed River, which may be due to both mining influence and communal-household pressures.

- 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

Maps

Map. Northern WBMA

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)