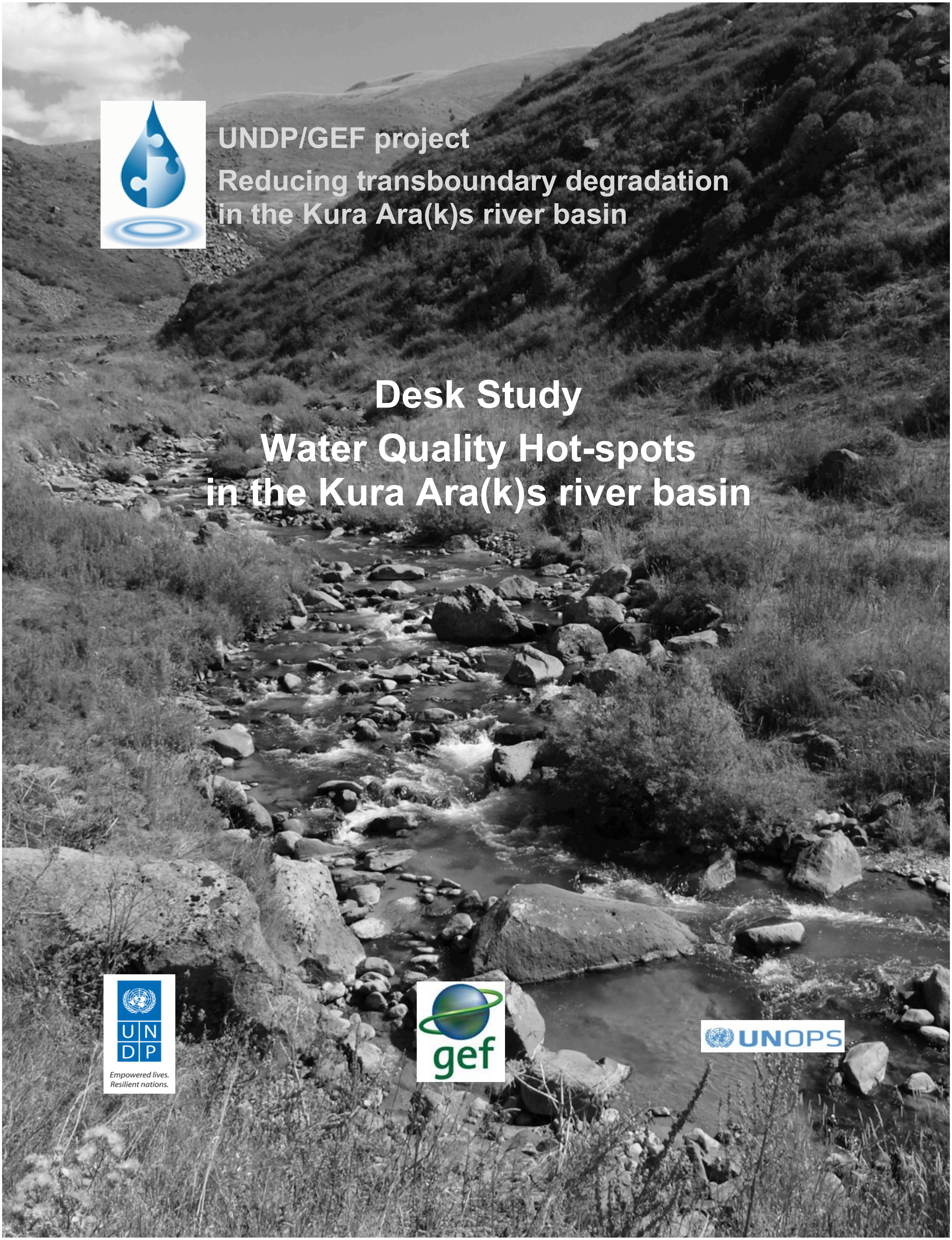

UNDP/GEF project

Reducing transboundary degradation in the Kura Ara(k)s river basin

Desk Study

Water Quality Hot-spots in the Kura Ara(k)s river basin

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REDUCING TRANSBOUNDARY DEGRADATION

IN THE

KURA ARA(K)S RIVER BASIN

Desk Study

Water Quality Hot-spots in the Kura Ara(k)s river basin

Tbilisi, Georgia – Baku, Azerbaijan – Yerevan, Armenia

September 2013

Empowered lives.
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DESK STUDY 3 WATER QUALITY HOT-SPOTS IN THE KURA ARA(K)S RIVER BASIN

The Water Quality Hot-spots Desk Study for the Kura Ara(k)s river basin, executed in the framework of the UNDP/GEF project "Reducing transboundary degradation in the Kura Ara(k)s river basin" focuses on providing an update regional overview of water quality throughout the Kura Ara(k)s river basin.

The information presented in this Desk Study is based on three individual National water quality reports, prepared in 2012 by qualified National Experts in each of Armenia, Azerbaijan and Georgia, upscaled to the regional transboundary river basin level by a qualified independent international expert.

The Water Quality Hot-spots Desk Study provides the background baseline information towards analysing priority water quality issues that are transboundary in nature, in accordance with the longitudinal changes along the river continuum between upstream and downstream countries. The water quality assessment and identified recommendations to address water quality at the river basin level are integrated in the Updated Transboundary Diagnostic Analysis (TDA) for the Kura Ara(k)s river basin. The Updated TDA as comprehensive analysis of transboundary issues provides a factual basis for the formulation of recommended options in the Strategic Action Program (SAP) towards improving the environmental situation and ensuring the sustainable development of the Kura Ara(k)s River Basin.

Colophon

Project title	Reducing transboundary degradation in the Kura Ara(k)s river basin
Financing	Global Environment Facility
Implementing Agency	UNDP United Nations Development Program
Executing Agency	UNOPS United Nations Office for Project Services
Chief Technical Advisor / Project Coordinator	Dr Mary M. Matthews
Report Editors	Harald J.L. Leummens & Mary M. Matthews
Lead Author	Eng. Ahmed Abu Elseoud
Contributions	Marine Arabidze, Matanat Avazova, Seyran Minasyan.
Suggested citation	Abu Elseoud A., 2013. Desk study – Water quality hot-spots in the Kura Ara(k)s river basin. UNDP/GEF project "Reducing transboundary degradation in the Kura Ara(k)s river basin", Tbilisi-Baku-Yerevan, 2013, 40 pp.

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ABBREVIATIONS AND ACRONYMS

AM	Armenia
AM-EIMC	Armenia Environmental Impact Monitoring Center
AM-MNP	Ministry of Nature Protection of Armenia
AZ	Azerbaijan
AZ-MEND	Azerbaijan National Environmental Monitoring Department
AZ-MENR	Ministry of Ecology and Natural Resources of Azerbaijan
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EU-WFD	European Union Water Framework Directive
GE	Georgia
GEF	Global Environment Facility
GE-MEP	Ministry of Environment Protection of Georgia
GE-NEA	Georgia National Environmental Agency
HPP	Hydropower plant
MAC	Maximum Allowable Concentration
PCB	Polychlorinated biphenyl
POP	Persistent Organic Pollutant
QA/QC	Quality Assessment / Quality Control
SAP	Strategic Action program
SOP	Standard Operational Procedure
TDA	Transboundary Diagnostic Analysis
TDS	Total Dissolved Solids
UN	United Nations
UNDP	United Nations Development Program
UNECE	United Nations Economic Commission for Europe
UNOPS	United Nations Office for Project Services
WWTP	Waste water treatment plant

LIST OF TABLES & FIGURES

1. INTRODUCTION

This document is the Water Quality Hot-spots Desk Study, which describes in detail the challenges of transboundary water resources management in the Kura Ara(k)s river basin to date, specifically those related to water quality monitoring, as well as the different policies and procedures that are currently being implemented in each country of the river basin.

The Desk Study is prepared as part of the Transboundary Diagnostic Analysis (TDA) for the UNDP/GEF project “Reducing Transboundary Degradation in the Kura Ara(k)s River Basin”. Unless otherwise stated, information in this document is based on three individual National Reports, prepared by qualified National Experts in each of Armenia, Azerbaijan and Georgia in 2012: Seyran Minasyan – Armenia Environmental Impact Monitoring Centre; Matanat Avazova – Azerbaijan National Environmental Monitoring Department; and Marine Arabidze – Georgia National Environment Agency.

The National water Quality Hot-spots reports were prepared following the decision of the UNDP/GEF Kura Ara(k)s Project Steering Committee in May 2012. The approach of preparing individual country reports by National Experts to be integrated in the underlying regional Water Quality Hot-spots Desk Study by an independent International Expert warranted making available the best available national-level water quality information from the countries’ national water quality monitoring while maintaining an unbiased regional interpretation of the outcomes.

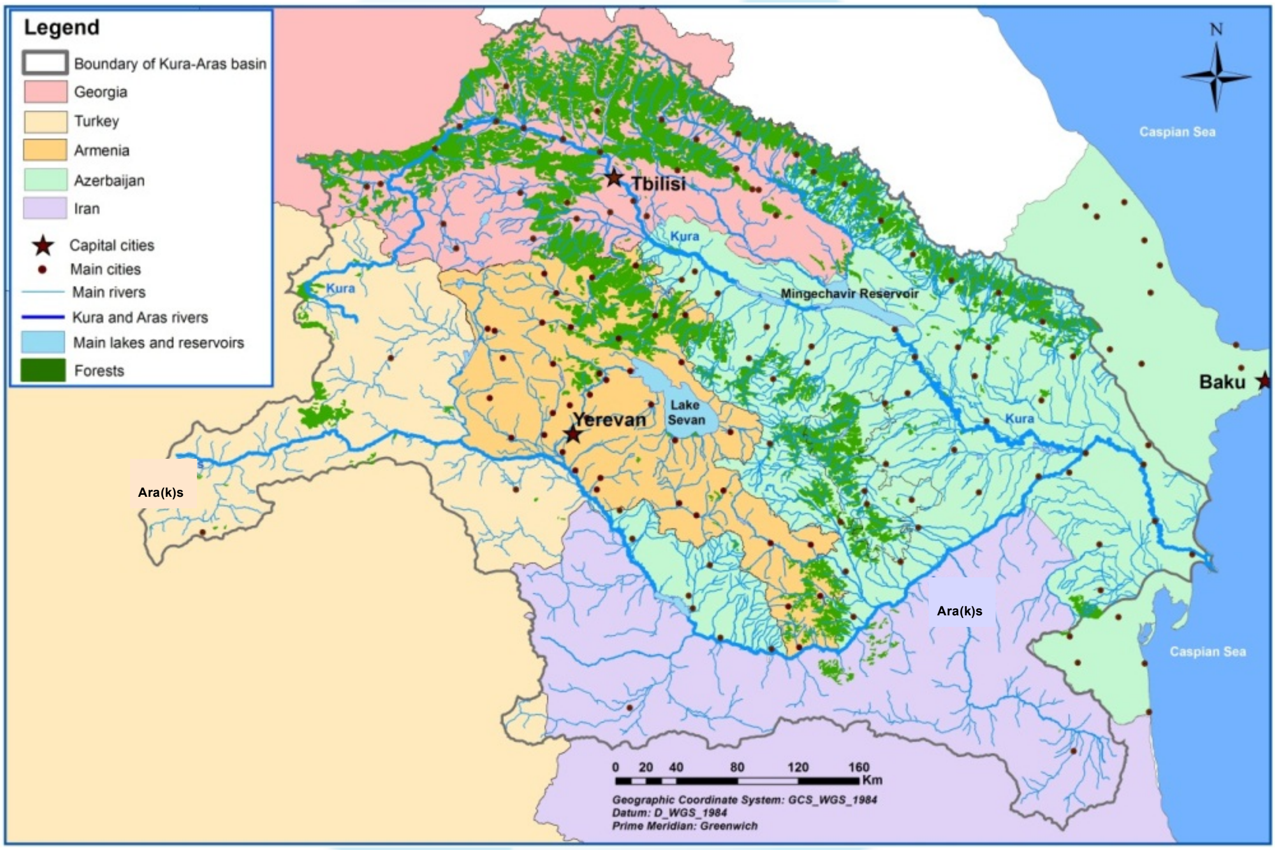
The Water Quality Hot-spots Desk Study provides for an initial baseline description, highlighting the main challenges faced in the region. In chapter 3 this includes a description of the national water quality monitoring programs for Armenia, Azerbaijan and Georgia, including the institutions involved in monitoring systems and standards. Based on data provided by each of the countries, a water quality assessment will be presented in chapter 4, including pressures on water resources for the Kura river basin and the Ara(k)s river Basin, the Alazani/Ganikh river basin and Iori river basin. Subsequently, in chapter 5 the major sources of water pollution within the basin will be discussed, while in chapter 6 the main water quality hot-spots will be identified. Finally, this report will provide conclusions based on the empirical data and recommendations for addressing the identified challenges to improve water quality management across the basin.

2 THE KURA ARA(K)S RIVER BASIN

2.1 General features

The Kura Ara(k)s river basin is located on the territory of Armenia, Azerbaijan, Georgia, the Islamic Republic of Iran and Turkey. The basin includes major transboundary tributaries - the Ara(k)s, Iori/Qabirri, Alazani/Ganikh, Debed, Aghstev/Agstafachay, Potskovi/Posof and Ktsia-Khrami (Figure 2.1).

Figure 2.1 Map of the Kura Ara(k)s river basin.



Note: Prepared by the UNDP/GEF Kura Ara(k)s project (2012).

2.2 Challenges facing the river basin

In the Preliminary TDA, published in 2007, water quality in the Kura Ara(k)s river basin was described as increasingly deteriorating in downstream direction for a number of parameters. The observed deterioration of water quality in the river basin is certainly a relevant and progressively increasing problem for the countries of the basin, especially also in relation to the increasing pressure on water resources in the region towards meeting the needs of future development plans, in addition to the potential impact of climate change on water quantity and quality in the region.

Polluting substances enter the water in the Kura Ara(k)s basin from various land-based sources, including industrial and mining enterprises, agricultural lands, houses and farms in rural areas, and especially from municipal sewer systems in urban areas. The quality of surface waters is also influenced by such factors as the hydro-morphological, hydro-geological and hydro-chemical features of the river basin. There are also other, less significant factors causing pressures on water quality of the river basin, such as the building of local and transnational roads.

Many cities and industries in the Kura Ara(k)s basin nowadays do not have sufficiently well-functioning waste water treatment plants (WWTPs). The existing WWTPs in the basin were largely built 25-30 years ago and most are now out of service. Those that are still functioning provide only a partial – mechanical - treatment, while biological and chemical waste water treatment in most parts of the basin is not provided. The limited number (and poor functioning) of treatment facilities, in the cities of Tbilisi and Rustavi in Georgia, in Gandja, Yevlakh, Mingechevir in Azerbaijan, and in Yerevan, Hrazdan and Vanadzor in Armenia, result in large amounts of untreated sewage water entering into the rivers, causing water pollution.

In the Kura river, a fairly high level of nutrients is observed in the Shikhli station downstream of the border between Georgia and Azerbaijan, an indication of the organic pollution load entering Azerbaijan due to the discharge of untreated/partially treated sewage water of Tbilisi and Rustavi. The concentration of nutrients decreases after the Mingechevir reservoir, due to the high velocity of the water released downstream of the dam, which replenishes the Dissolved Oxygen (DO) concentrations. Further downstream the concentration of nutrients and salts in the river water continues to increase again, suggesting the discharge of large volumes of untreated water into the main river and its tributaries, from agricultural areas, farms, and especially the urban municipal sewer systems in the cities of Azerbaijan.

The absence or poor functioning of existing treatment facilities is also a problem throughout the Ara(k)s river basin in Turkey, Armenia, Azerbaijan and Iran, providing for large volumes of untreated sewage water to enter the river and its tributaries. This causes issues of downstream pollution in all basin countries, including transboundary ones. Waste water treatment is a rare luxury in rural areas of Armenia, and domestic waste water is subjected to either direct disposal to water bodies or land. The same is true for most of settlements in the Ararat Valley, where the groundwater table is relatively high, causing a high risk of contamination of groundwater aquifers with domestic waste water and fertilizers.

Meanwhile, the increased concentrations of components like sulfate, total dissolved salts (TDS) and others in the lower reaches of the Kura and Ara(k)s rivers also result from hydro-chemical processes. In addition, also the background concentrations of chromium, copper, vanadium, nickel and some other metals are particularly high in the mineral-rich Kura Ara(k)s basin. The metal content in water and sediments of the Kura and Ara(k)s rivers and their transboundary tributaries is further increased by human activities, particularly mining, in some parts of the basin (Armenia, Georgia).

At the same time, technologies used in agriculture, industry, mining, recycling of household and industrial waste as well as water management activities in the Kura Ara(k)s river basin are outdated and not environmentally friendly.

All the three countries in the basin count on the natural phenomena of diluting the pollution load directly discharged in the river stream with running fresh water. These phenomena depend on the water quantity and quality features of the discharged water as well as the receiving water body. Accordingly, the seasonal variability of water flow volumes in the Kura Ara(k)s river basin has direct impact on its water quality. During the high-flow period, characterized by high volumes of water discharged and high water velocities, the dilution of an equal pollution load in a larger volume of water will result in lower concentrations of polluting substances in the receiving water body. In addition, the high flow velocity of water during the high-flow periods in the mountainous rivers replenishes the DO concentration and reduces the nutrients load. On the opposite, during the low flow seasons, when the volume of water transported by the river reaches its minimum and water velocities are at their lowest, an equal pollution load will impact much more on the water quality in the downstream section of the river, causing increased concentrations of polluting substances. Therefore, using the annual average concentrations of pollutants as an indicator for the water quality in a river may be misleading, because in the high-flow season the water in the river may show a good quality, while during the low flow season concentrations may exceed the allowable limits.

Although the dilution of pollution is not a proper solution for the ecosystem sustainability, the countries at present are forced to use water bodies as recipients of polluted water from different sources, due to the lack of finances and investments to build/operate wastewater treatment facilities. In this, the countries rely on the assimilation capacity of its rivers to dilute and “treat” the pollution load. In order to approach sustainability, however, it is crucial to develop a long term plan to construct WWTPs at or near all pollution sources to properly treat the waste water before discharging it back into the rivers. While this investment plan may take 15-20 years to be implemented, for the short term the countries should develop environmental management plans to control the volume of waste water discharged to the river from different sources during the low flow season, by designing and maintaining environmental flow requirements in each river. As such the quality of water in the river during the low flow periods can be improved.

A challenge facing the proper integrated management of water quality in the Kura Ara(k)s river basin is the lack of a uniform or compatible system of standards and methods to assess the chemical and ecological status of water quality in riparian countries. Because of this, an identical concentration of a specific substance in water provides for a different chemical water quality assessment in different countries: possibly varying from "background condition" to “polluted” for the same concentration of a parameter in the same water body. At present the government systems of standards and water quality assessment in most riparian countries do not take the natural features of the basin into account; they are mainly based on the old Soviet standards and assessment approach. In 2011, Armenia was the first country to adopt a new system of standards based on a 5-class assessment for chemical water quality taking background concentrations of components into account. Studies have been initiated in the both Azerbaijan and Georgia to develop new water quality standards comparable to the methodology applied in Armenia, but this process is not yet finalized and the two countries are still applying the old Soviet system of standards.

3. NATIONAL WATER QUALITY MONITORING PROGRAMS

This section of the report will cover the institutional set-up for water quality monitoring activities at the national level in each of the project countries Armenia, Azerbaijan and Georgia. Besides focusing on describing the national water quality monitoring programs that are operating in each country, also the availability of data and information for water quality monitoring in the river basin with its geographical and temporal coverage will be discussed. The list of pollutant parameters as well as the maximum allowable concentrations for each pollutant according to the national laws and regulations will be described. The available standard operational procedures (SOPs) for each monitoring program will be discussed, including the analytical methodologies for each pollutant parameter measured, as well as the quality control and quality assurance procedures for validation of monitoring data.

3.1 Institutions for water quality monitoring

Even though the water of the South Caucasian countries is a common resource, joint programs on monitoring the transboundary rivers are implemented exclusively in the framework of international projects. Table 3.1 presents the basic characteristics of the National Water Quality Monitoring programs in each of the three countries Armenia, Azerbaijan and Georgia.

In Armenia, surface water quality monitoring is carried out by the Environmental Impact Monitoring Center (AM-EIMC) under the Ministry of Nature Protection (AM-MNP). The AM-EIMC is not only monitoring surface water quality, but it is also involved in monitoring of air and soil quality. The water quality monitoring section consists of 3 analytical groups: the physical-chemical analytical group; the spectrophotometric analytical group; and the chromatographic analytical group. Each group handles the analysis of specific water quality parameters.

In Azerbaijan, surface water quality is carried out by the National Environmental Monitoring Department (AZ-NEMD) under the Ministry of Ecology and Natural Resources (AZ-MENR). The AZ-NEMD includes 9 laboratories, of which 3 are responsible for monitoring surface water quality: the Geochemical Regime and Pollution Monitoring Laboratory of Natural Waters monitors water quality of rivers and lakes in the country; the Gazakh Analytical Research Laboratory monitors water quality of the transboundary Kura river, and the Horadiz Analytical Research Laboratory monitors water quality of the transboundary Ara(k)s river.

In Georgia, surface water quality monitoring is carried out by the National Environmental Agency (GE-NEA), established as a legal independent entity within the Ministry of Environment Protection of Georgia (GE-MEP). NEA's Department of Environmental Pollution Monitoring is responsible for the monitoring of surface water quality on a regular basis. Analytical work is executed in three laboratories - in Tbilisi, Kutaisi and Batumi.

Table 3.1 demonstrates that the three countries all are conducting national monitoring programs for surface water quality in rivers and streams for a set of basic pollutants. The number of pollutants included in the monitoring programs varies: in Armenia an extensive monitoring program covering a wide spectrum of 105 pollutants, while in Azerbaijan and Georgia the monitoring program covers 25 and 36 parameters respectively. The frequency of monitoring is largely once per month, increasing to once every 10 days in Azerbaijan at its key transboundary sites. This reflects the importance of these sites for water management in Azerbaijan, as they provide information on the quality of water entering the country.

Table 3.1 Features of the national water quality monitoring programs in Armenia, Azerbaijan and Georgia.

Parameter	Armenia	Azerbaijan	Georgia
Total length of water bodies	About 9,480 small and large rivers, with a total length of about 23,000 km.	In total 8,350 rivers with a total length of 33,665 km.	More than 26,000 rivers with a total length of about 59,000 km.
Total number of monitoring stations	140	44	43
Total number of transboundary stations			
Number of staff	30	19	41
Equipment availability	1 ISP-MS; 3 spectro-photometers; 4 Gas chromatographs; 1 ion chromatograph; 3 multi parameter meters.	2 spectrometers; 2 spectro-photometers; ionometer; conductivity meter; PH meter; turbidity meter; DO meter.	1 AAS; 2 spectrometers; 2 spectro-photometers; 2 gas chromatographs; 1 ion chromatograph; conductivity meter; PH meter; turbidity meter; DO meter.
Water Quality parameters measured	105 parameters.	25 parameters.	36 parameters (physical, chemical, microbiological).
Frequency of monitoring	From 7-12 times a year with total number of samples (1,400-1,600) per year. Transboundary sites: once per month.	Monthly for: temperature, pH, dissolved oxygen, electrical conductivity, turbidity, color, smell, oil and grease, phenols, superficial active synthetically substances, heavy metals. Quarterly for all parameters. Transboundary sites: once every 10 days.	Once per month.

Note: data provided by the National Experts in 3 National Technical Reports on water quality.

The major challenges facing water quality monitoring in the three countries are rather similar, and can be summarized as follows:

- Maintaining staff is a major challenge in all three countries. High turnover rates in qualified staff, having been trained and obtained relevant experience is largely caused by the availability of more attractive opportunities in the private sector, providing more competitive salaries.
- Insufficient financial resources to implement full scale Quality Assurance/Quality Control (QA/QC) procedures.
- Insufficient financial resources to upgrade/maintain monitoring laboratory equipment.
- Absence of a national reference laboratory in each country, to provide technical assistance and guidance on laboratory procedures related to sampling and analysis of fresh water resources.

3.2 Laboratory analytical methods

An analytical method is a procedure that determines the concentration of a contaminant in a water sample. Analytical methods generally describe:

- How to collect, preserve, and store the sample.
- Procedures to concentrate, separate, identify, and quantify contaminants present in the sample.
- Quality control criteria the analytical data must meet.
- How to report the results of the analysis.

In general, an analytical method:

- Is applicable to routine analyses of samples.
- Is suitable for measuring the river water contaminant in the concentration range of interest.
- Provides data with the necessary accuracy and precision to demonstrate compliance or meet monitoring objectives.
- Include instructions for all aspects of the analysis from sample collection to data reporting.
- Incorporates appropriate quality control criteria so that acceptable method performance is demonstrated during the analysis of samples

For example, table 3.2 shows the analytical methods used in laboratory analysis for the different parameters for both Georgia and Armenia. There is similarity in the analytical methods used for the basic pollutant parameters in the two countries. However, the accuracy and level of precision in the laboratory results does not depend only on the analytical method used, but it also depends on the laboratory staff capabilities and the equipment used in the analysis. The full implementation of the quality systems Standard Operation Procedures (SOPs) should guarantee that the receiving laboratories are fully capable to reliably generate results that are comparable and compatible to each other. The participation in the proficiency testing (comparative testing) is an important way of meeting the requirements of ISO/IEC 17025 in the area of quality assurance of laboratory results. It is also mandated by accreditation bodies that laboratories participate in proficiency testing programs for all types of analyses undertaken in that laboratory, when suitable programs exist.

Proficiency testing involves a group of laboratories or analysts performing the same analyses on the same samples and comparing results. The key requirements of such comparisons are that the samples are homogenous and stable, and also that the set of samples analyzed are appropriate to test and display similarities and differences in results. The proficiency tests are preformed through a regional laboratory functioning as a center of expertise and standardization in the laboratory analysis of water samples. As there is no regional reference laboratory for water in the south Caucasian countries, they should register with one of the internationally recognized reference laboratories in order to participate in periodical tests on their laboratories performance to ensure that the monitoring results produced from all the three countries will be on the same level of accuracy and precision.

Table 3.2 Laboratory analytical methods for water quality parameters in Georgia and Armenia.

Parameter	Armenia		Georgia	
	Method	Description/type of equipment	Method	Description/type of equipment
Temperature		HORIBA U-10 MULTI-PARAMETER zond/Oxi 330i/340i Germany		YSI Water Quality Multi-parameter Meter 6600 (in situ)
Color	ISO 7887	Organoleptic		
Transparency	EPA 213 1998	Nephelometric method		
pH	EL. Metrical	pH 330i/340i	ISO 10523	Potentiometric method
TDS	SFS-EN 872	Method by filtration	ISO 11923	Gravimetric method
Carbonate		Titrimetric	Guidelines for the Chemical analysis of wastewater -77	Titration method
Carbon dioxide		Titrimetric		
DO	(EPA 2540)1998	HORIBA U-10 MULTI-PARAMETERzond/Oxi 330i/340iGermany	ISO 5814:1990;	Electrochemical method
BOD1 / BOD5	ISO 5815	Spectrometric method	ISO 5815	Electrochemical method
Nitrite Nitrogen	ISO 10304-1 :2007	ION Chromatograph ICS 1000	ISO 10304	Ion Chromatograph
Nitrate nitrogen				
NH_4^+ Nitrogen	ISO 7150-1	Photocolorimetrical	ISO 7150-1	Spectrophotometric method
Orthophosphate	ISO 10304-1 :2007	ION Chromatograph ICS 1000	ISO 10304	Ion Chromatograph
Sulphate	ISO 7150-1	Photocolorimetrical		
Chloride	ISO 10304-1 :2007	ION Chromatograph ICS 1000		
Potassium	ISO 9964	Light-photometrical method		
Sodium	ISO 996	Light-photometrical method		
Calcium	ISO 6059	Titrimetric method		Titration method
Magnesium	ISO 6059	Titrimetric method		Titration method
Conductivity	PA2520-1998; ISO 788-1985	HORIBA MULTI-PARAMETERzond/Cond. 330i/340iGermany		
Salinity	PA2520-1998; ISO 788-1985	HORIBA MULTI-PARAMETERzond/ Cond. 330i/340iGermany		
Zn, Cu, Pb, Ni, Mn, Fe	ISO8288	Atom-Absorption spectrometer	ISO 17294	Inductively coupled plasma Mass-spectrometry method
TPH	ISO6468-1996 EPA 6630c	Gas- Chromatographical method		
PAH				ISO 10695
Pesticide				ISO 6468
Phenol	ISO6439-90/RD118.02.012-88	Spectrometric method		
E-coli	9308-1	Membrane filtration method		
Total viable count	SOP	Method for the enumeration of heterotrophic bacteria		
Streptococcus Faecalis	ISO7899-2	Membrane filtration method		
Total coli forms	9308-1	Membrane filtration method		

3.3 Water quality standards

Before the break-up of the Soviet Union, river water quality assessment was based on a framework of the decrees adopted by the Soviet officials, defining the Maximum Allowable Concentrations (MAC) of each polluting substance. These limits were technically not correct, since they were uniformly applied throughout the whole Soviet territory, without taking hydrological, morphological, as well as geological variation of the basins characteristics into account.

Since independence, Azerbaijan and Georgia are still using the same system of water quality assessment standards based on one specific MAC value per pollutant. Meanwhile Armenia has adopted a more advanced approach, in which the norms are basin-specific, taking the variation in environmental conditions between basins into account. On January 27, 2011 the Government of the Republic of Armenia adopted a decree defining the 14 largest river basins in the country as well as the surface water quality standards in the river basins. Based on the natural background values of substances in water, these standards define the permissible substances' concentrations in different parts of the water body. Thus, the decree provides for different quality status within the same river. Under the standards used at the Soviet times, pollution assessment of a substance was classified in relation to its single MAC indicator, and pollution expressed as a multiplier of exceeding the MAC, absence of pollution expressed by the substance concentration not exceeding the MAC. With the current standards, surface water quality assessment is based on a 5-class approach: “excellent”, “good”, “moderate”, “poor” and “bad”. Table 3.3 presents an overview of the current permissible limits in force in Armenia, Azerbaijan and Georgia, with for Armenia the Meghri river chosen as an example of the basin-specific water quality standards.

As shown by table 3.3, there is, however, no international agreed set of physicochemical standards to assess transboundary surface waters in a comparable way, as the existing country-level standards define different numbers of quality classes and different values for identical parameters. The absence of a unified interpretation system makes disputes about the quality status of transboundary waters inevitable. Accordingly, there is a need for a common approach in water quality standards and assessment to be used in the three riparian countries. The current Armenian methodology for setting water quality standards can be used as the basis for developing a common standard for the transboundary waters.

Meanwhile, the EU Water Framework Directive (EU-WFD) requires an ecological approach to water quality assessment and the definition of ecological quality objectives for water bodies. This requires reliable and extensive biological monitoring data to be available, which currently is not the case in the three riparian countries. The Demonstration Project component being implemented in the framework of the UNDP/GEF Kura Ara(k)s project will strengthen the capabilities of the riparian countries in bio-monitoring, and will provide support towards institutionalizing bio-monitoring into national water quality monitoring programs.

Table 3.3 Current water quality standards in Armenia, Azerbaijan and Georgia.

Parameter	Unit	Armenia					Azerbaijan	Georgia
		excellent	Good	moderate	poor	Bad		
pH							6.5-8.5	6.5-8.5
DO		>7	>6	>5	>4	>4	4 – 6	4 – 6
BOD_5	mg/l	3	5	9	18	>18	3.0	3.0
COD	mg/l	10	25	40	80	>80		
NO_2^- Nitrogen	mg/l						0.08	1.0
NO_3^- Nitrogen	mg/l						40	10
NH_4^+ Nitrogen	mg/l						0.5	0.39
Potassium K	mg/l							50
Orthophosphate	mg/l							3.5
Sulphate SO_4	mg/l							500
Chloride Cl	mg/l							250
Sodium Na	mg/l							200l
Calcium Ca	mg/l							180
Magnesium Mg	mg/l							40
Zinc Zn	mg/l	0.0032	0.1	0.2	0.500	>0.500	1.0	1.0
Copper Cu	mg/l	0.0042	0.0242	0.050	0.100	>0.100	1.0	1.0
Lead Pb	mg/l	0.00015	0.0102	0.025	0.050	>0.050		0.03
Nickel Ni	mg/l	0.00083	0.01083	0.050	0.100	>0.100	0.1	0.1
Manganese Mn	mg/l	0.007	0.014	0.028	0.056	>0.056	1.0	0.1
Iron Fe	mg/l	0.000086	0.000172	0.005	0.001	>0.001	0.5	0.3
Phenol	mg/l						0.001	0.001
E-coli	count/l							5,000
Streptococcus Faecalis	Absent in 250 ml							
Total coli forms	Absent in 250 ml							

Note: For Armenia, the water quality standards as adopted for the Meghri river basin are presented as example of the approach; For Azerbaijan and Georgia – MAC values.

4. WATER QUALITY ASSESSMENT

This section will analyze the available quantitative water quality monitoring data at the national level, with emphasis on the major pollutants of concern. The analysis will discuss the geographical distribution of pollutants within the basin countries, as well as temporal trends. This section will provide a general overview of the river water quality issues with emphasis on the transboundary issues.

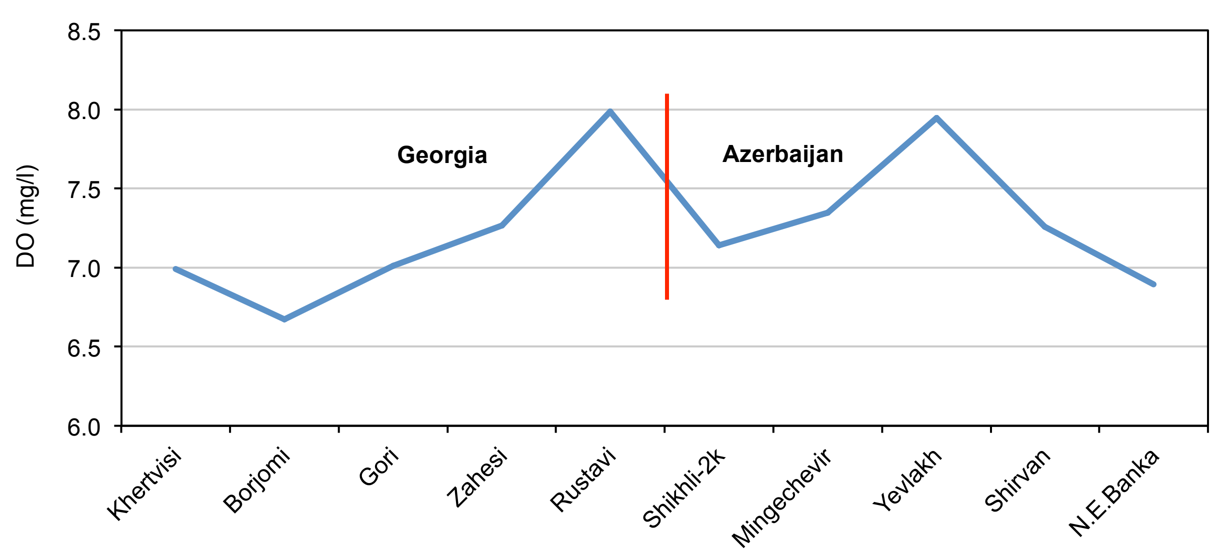
4.1 The Kura river basin

The observed pH values are normal and typical for mountainous rivers, especially in the upper reaches of the basin in both Georgia and Armenia. Although the river become quite low towards its delta in Azerbaijan, the average annual concentration of pH still in good conditions and varies from 8.0 to 8.2 in all the stations in Azerbaijan during the last 5 years.

Dissolved Oxygen (DO) refers to the amount of oxygen dissolved in river water, and hence available to sustain aquatic life. DO is the most important indicator of the health of a water body and its capacity to support a balanced aquatic ecosystem of plants and animals. Wastewater containing organic - oxygen consuming - pollutants depletes the DO and may cause death of aquatic organisms.

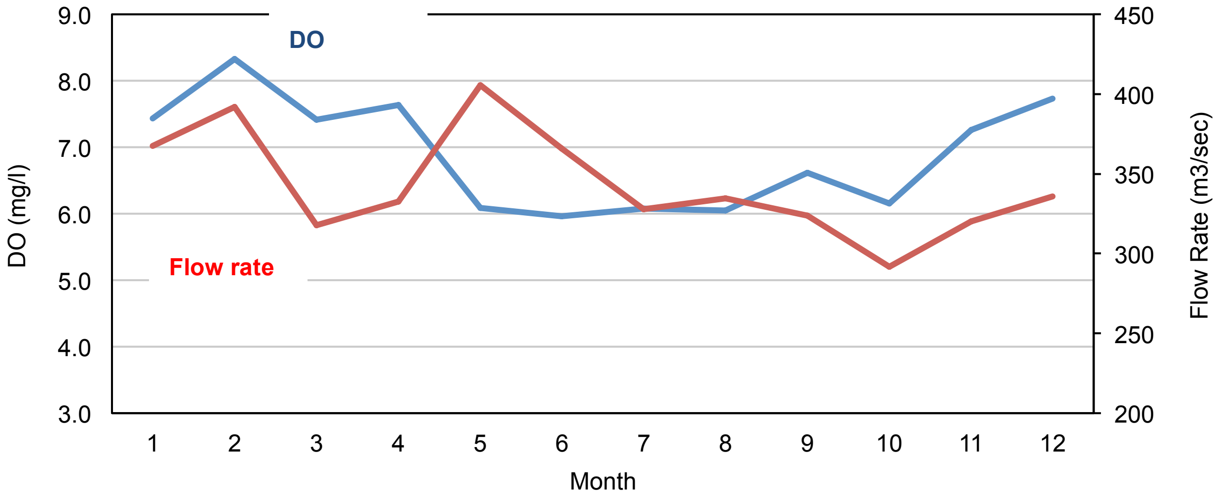
The average annual concentration of DO in the Kura river basin is satisfactory or higher, largely exceeding 7 mg/l (figure 4.1), conditioned by the rather natural hydro-morphological conditions and hydrological regime of the river. The higher the flow rate, the higher the DO concentration. The lowest concentration of DO was measured at Borjomi in Georgia and N.E. Banka in Azerbaijan. The DO increased in downstream direction in Georgia, reaching a maximum concentration at Rustavi, just before the outfall of the Tbilisi WWTP. The impact due to waste water from the WWTP is clearly shown in the DO reduction from almost 8 mg/l in Rustavi, to 7.2 mg/l in Shikhli, across the border in Azerbaijan.

Figure 4.1 Average concentration of DO in the Kura river.



Note: Calculations based on averaging monthly data collected during years 2007-2011.

Figure 4.2 Relation between average monthly DO concentration and river flow in N.E. Banka (Azerbaijan).



Note: Calculations based on averaging monthly data collected during years 2007-2011.

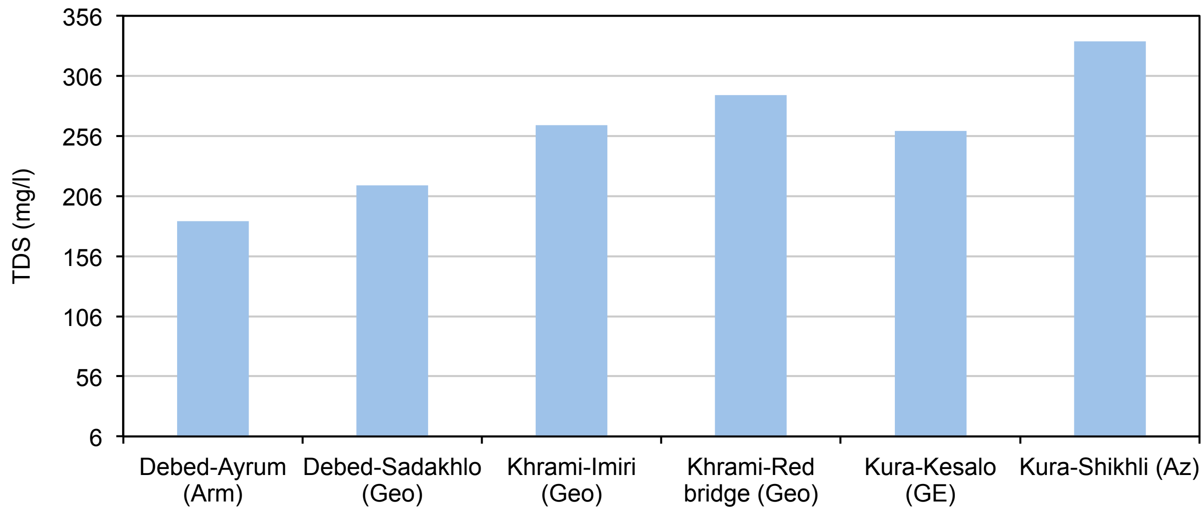
Figure 4.2 shows the variation in average monthly DO concentrations at N.E. Banka in Azerbaijan for the period 2007-2011. The average monthly DO concentration decreased to about 6 mg/l during the period May-October, with a minimum value (5.96 mg/l) in June. Between November and April the DO concentration increases again, related to an increase in water flows in the river. The period May-October represents the period of high agricultural water demands, with farmers abstracting water from the river for irrigation purposes. Consequently also agricultural drainage water is released back into the river, containing organic and chemical pollutants, which could be one of the causes explaining the decrease in DO during summer in this tail-end station along the river. An additional, albeit more constant, contributing factor is the release of untreated or partially treated municipal waste water into the rivers.

Total Dissolved Solids (TDS) refers to the amount of all inorganic and organic substances, - minerals, salts, metals, cations or anions – dispersed in a volume of water. By definition, these solids must be small enough to be filtered through a 2 μm sieve. TDS concentrations are equal to the sum of positively charged ions (cations) and negatively charged ions (anions) in the water. Sources for TDS include agricultural run-off, urban run-off, industrial waste water, municipal sewage water, and natural sources such as leaves, silt, plankton, and rocks. Piping or plumbing may also release TDS into the water.

Figure 4.3 shows the variation in average annual TDS concentration in 2009 along the Kura river across the Armenia-Georgia border and the Georgia-Azerbaijan border. The TDS concentration varies from 185 mg/l at Debed-Ayrum (Armenia) to 335 mg/l at Shikhli in Azerbaijan. The low TDS values are related to the natural conditions and the hydro- and geo-chemical features in the upper and middle reaches of the river basin, while the anthropogenic influence is low. In Georgia, the average monthly TDS values also vary in the range of 200-400 mg/l (data for 2004-2006).

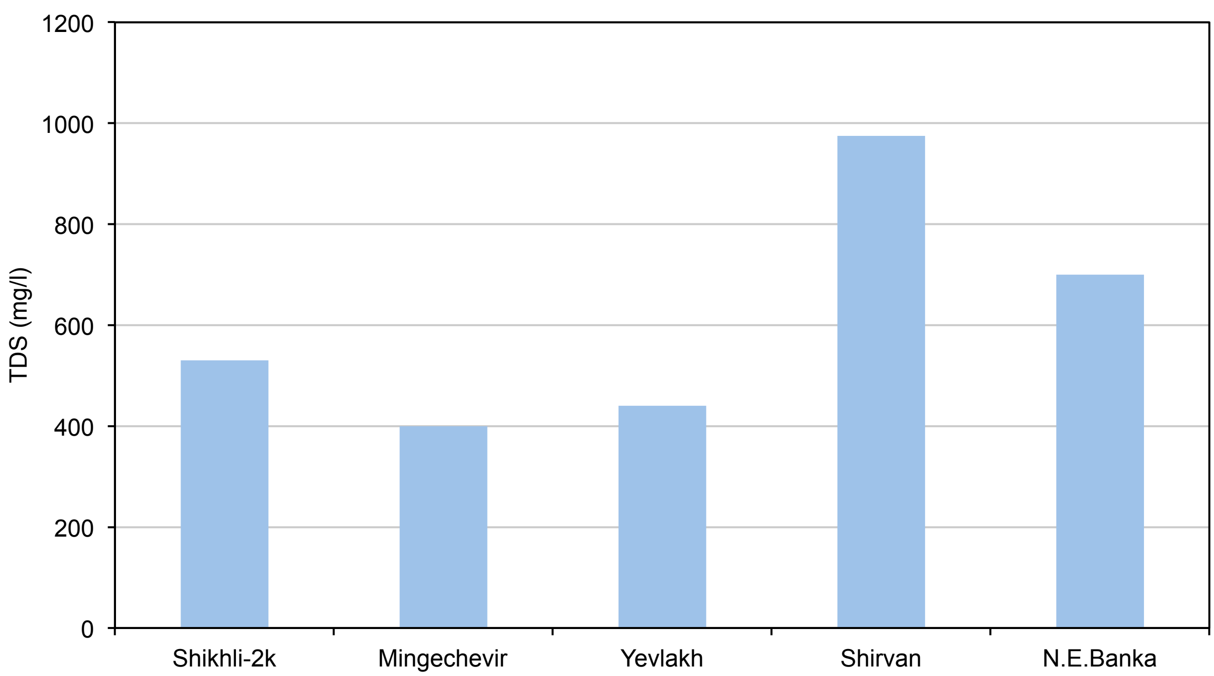
In Azerbaijan, the hydro-morphology and geochemistry of the basin are different. Figure 4.4 presents an increasing trend of average annual TDS values in downstream direction, especially after the Mingechevir reservoir. Towards the river mouth probably the interaction of river water with very saline groundwater intensifies, enriching river water with dissolved salts and, in particular, sulfates. The high TDS at Shirvan, located about 45 km downstream of the confluence of the Kura and Ara(k)s rivers at Sabirabad, may reflect slower flow velocities in the lowland river stretches, providing greater solute acquisition opportunities and contributions from solute-rich agricultural runoff.

Figure 4.3 TDS concentration at transboundary locations in the Kura river basin in 2009.



Source: EU (2011).

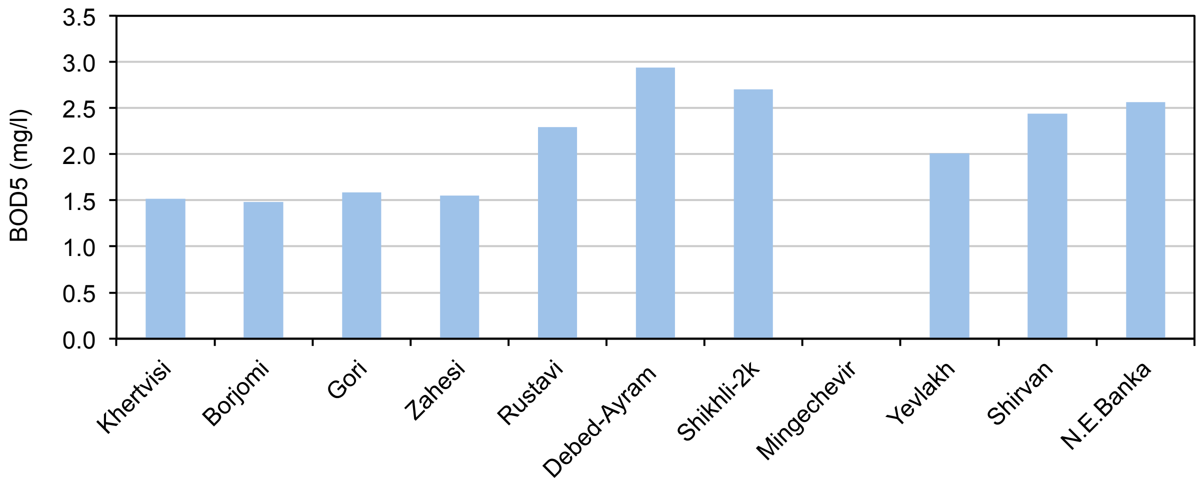
Figure 4.4 Monthly TDS concentration for stations along the Kura river in Azerbaijan in 2010.



Biological Oxygen Demand (BOD_5) indicates the amount of oxygen needed for the biological degradation of organic substances in water in mg O_2/l. The BOD test is based on the activities of bacteria and other aerobic microorganisms (microbes), feeding on organic matter in the presence of oxygen. The result of a BOD_5 test indicates the amount of water-dissolved oxygen, expressed as parts per million or milligrams per liter, consumed by microbes incubated in darkness for five days at an ambient temperature of 20°C. The higher the BOD value, the higher the amount of organic matter from pollution in the sample.

Figure 4.5 presents the annual average concentration of BOD_5 in the Kura river during the period 2007-2011. It shows that the BOD_5 is less than 3 mg/l, the limit for water under pressure, at all measured sites.

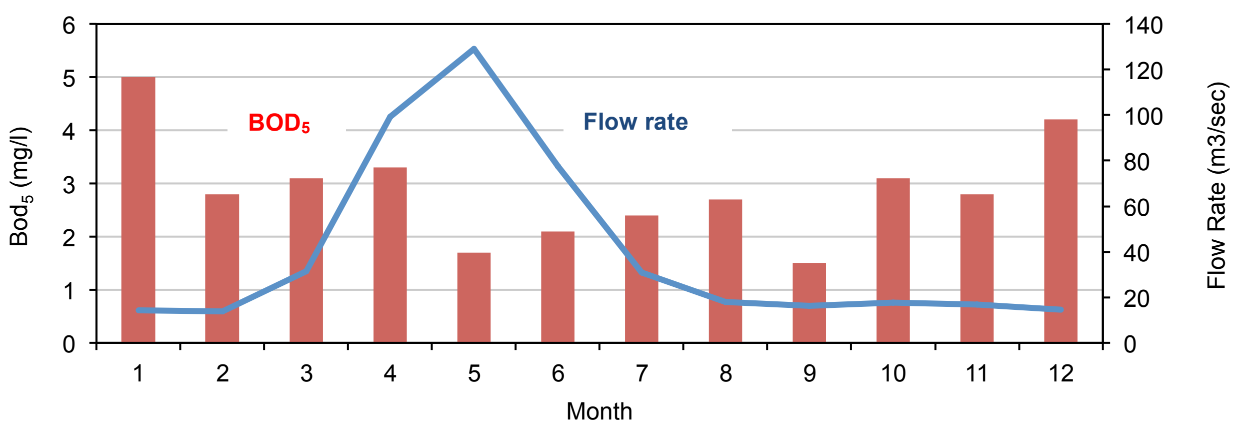
Figure 4.5 Average annual concentration of BOD_5 at transboundary locations in the Kura river.



Note: Average values based on monthly observations for the period 2008-2011.

Figure 4.5 shows that at Khertvisi, downstream of the Turkey-Georgia border, the BOD_5 is low, water is oligotrophic and of good quality. At Shikhli, downstream of the Georgia-Azerbaijan border, the BOD_5 value has almost doubled, indicating pollution with organic substances. However, the value of BOD_5 exceeds the norm of 3 mg/l only in 10-20% of all water samples analyzed, suggesting that the combination of specific hydrological regime, the natural features of the river basin, especially its mountainous character in the upper and middle reaches, causes a rather fast oxidation of organic substances. Another suggestion can be the possibility of low level of organic load entering the river in the upper and middle reaches as a result of low anthropogenic activities in these regions, but not enough data are available to analyze this issue on the level of discharges from different sources along these reaches.

Figure 4.6 Relationship between monthly average concentration of BOD_5 and flow rates at the Debed-Ayrum monitoring station (Armenia).



Note: Average values based on monthly data for period 2008-2011.

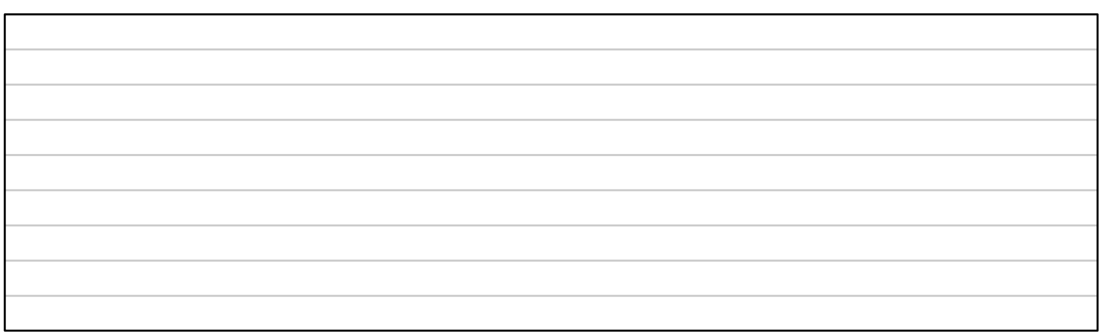
Figure 4.6 presents the relationship between the average monthly BOD_5 concentration and the monthly flow rate at Debed-Ayrum in Armenia near its border with Georgia, upstream of the confluence with the Khrami river in Georgia. During the low flow seasons the average BOD_5 concentration reaches 5.0 mg/l, which exceeds the MAC of 3 mg/l according to Georgian standards by more than 60%, while the average annual concentration for this station does not exceed the MAC. This clearly shows that using average annual concentrations as the sole indicator for river water quality may not be sufficient to accurately assess the status of water quality, but that the seasonal variability of the pollutant concentrations must be taken into consideration, especially in rivers with a high seasonal variability in water flow volumes.

Figure 4.6 also demonstrates the inverse relationship between flow rate and the BOD_5 concentration, with high flow rates leading to higher water velocities which increase the DO content in the water, which consequently decrease the BOD_5 concentrations. A higher flow rate also contributes to the dilution of any pollution load, reducing pollutant concentrations. During low flow seasons, an equal pollution load released to the river will show higher BOD_5 concentrations, up to values exceeding the MAC of 3 mg/l. At Debed-Ayrum this is observed during 5 months of the year, which hints at a high organic load released with untreated sewage water from residential areas along the Debed river. This load merges with the pollution load of the Khrami river, to discharge into the Kura river at the Georgian-Azerbaijan border.

Ammonium (NH_4^+) is the ionized form of ammonia (NH_3), which occurs when the water is acidic. The degree to which NH_3 forms NH_4^+ depends on the pH of the river water. If the pH is low, more NH_3 molecules are converted into NH_4^+ ions, while when the pH is high the hydroxide ion abstracts a proton from the NH_4^+ ion, generating NH_3. When NH_4^+-nitrogen levels in surface waters are too high, they can be toxic to some aquatic organisms. On the other hand, if the levels are only moderately high, plant and algal growth will usually increase, due to the abundance of nitrogen available as a nutrient. Accordingly, this will impact on other water quality attributes, such as increasing the BOD_5 and lowering DO levels. DO levels can also be lowered when NH_4^+ nitrogen is high due to the increased occurrence of nitrification.

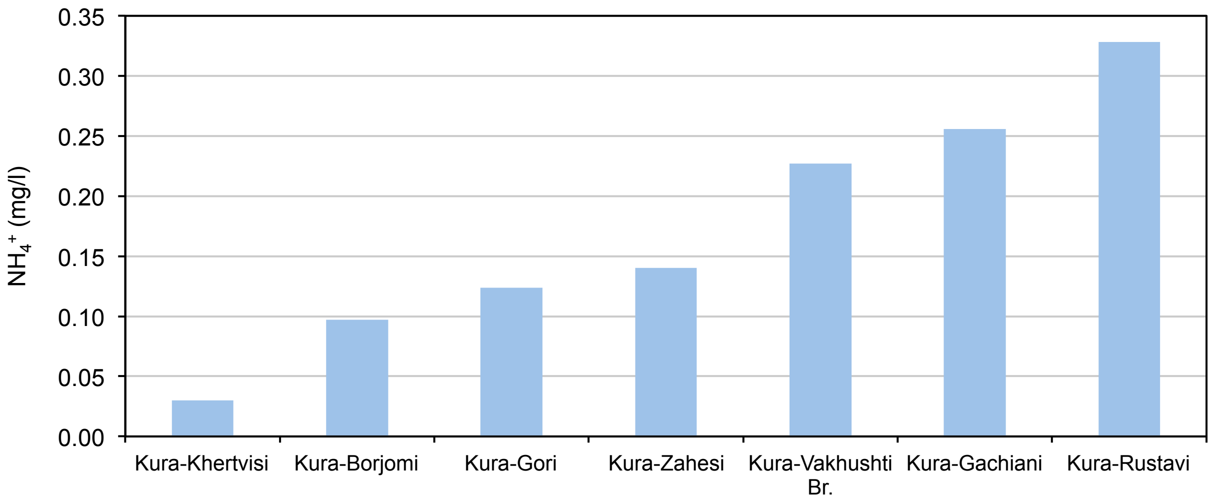
Figure 4.7 shows the average annual concentration of NH_4^+ for the monitoring stations Debed-Ayrum in Armenia, Kura-Rustavi in Georgia and 5 monitoring stations along the Kura river in Azerbaijan. Figure 4.7 shows two trends in increasing NH_4^+ concentrations. The first trend is transboundary, with the NH_4^+ concentrations increasing between Rustavi and Shikhli (Azerbaijan), related to the discharge of untreated waste water from the Gardabani WWTP, which operates with a low efficiency and provides only mechanical treatment. After the Mingechevir reservoir the NH_4^+ concentrations decrease, due to the trapping of most sediments and nutrients carried by river water in the reservoir. The second trend of increasing NH_4^+ is observed between Yevlakh and N.E. Banka, a result of the local impacts of untreated waste water released from villages and farmlands in the vicinity of the river, in addition to the outflow of agriculture drainage water with high nutrients load.

Figure 4.7 Average annual concentration of NH_4^+ in the Kura river.



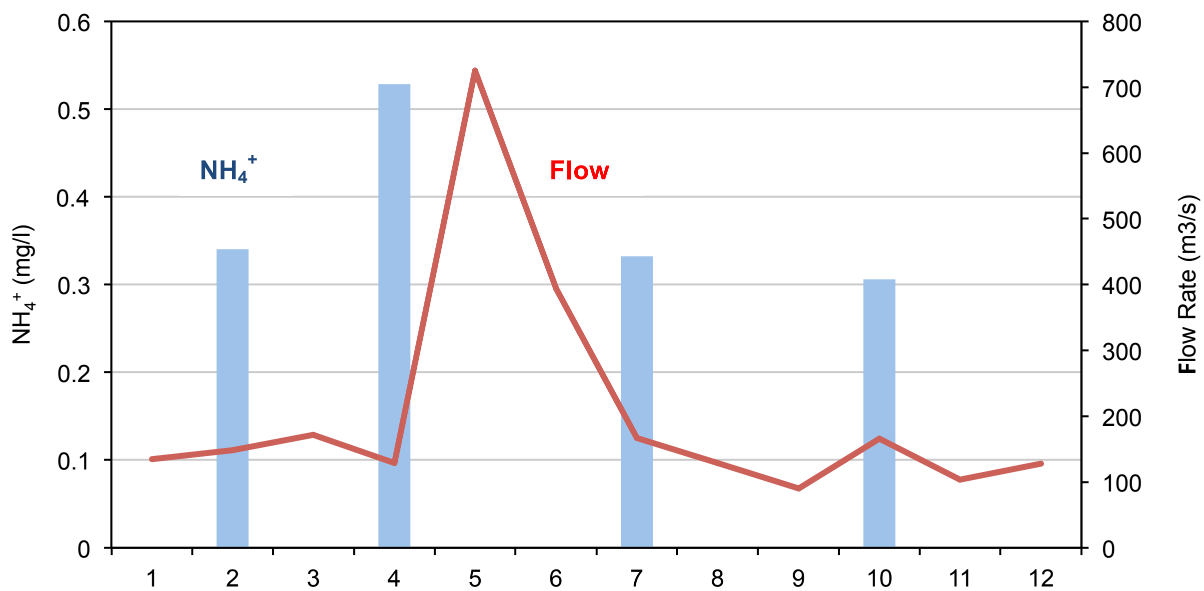
Note: Based on monthly data for the period 2007-2011, except for Rustavi – 2007-2010.

Figure 4.8 Average 2010 concentrations of NH_4^+ at locations along the Kura river in Georgia.



In figure 4.8 the average annual NH_4^+ concentration in 2010 for different monitoring stations in Georgia shows an increasing trend in downstream direction from Khertvisi near the Turkey-Georgia border towards Rustavi upstream of Georgia-Azerbaijan border. This trend is typical for river water impacted by municipal waste water and agricultural drainage water, causing an increasing organic pollution load from upstream to the downstream section of the river. Meanwhile, even at the Rustavi monitoring location the observed average annual NH_4^+ concentration is still below the MAC adopted in Georgia (0.39 mg/l).

Figure 4.9 Relationship between monthly average NH_4^+ concentrations and flow rates at Shikhli (Azerbaijan).



Note: Average values based on measured data during the period 2007-2011.

Figure 4.9 presents the monthly average concentrations of NH_4^+ at Shikhli, the entrance point of the Kura river into Azerbaijan, located downstream of the main outflow canal from the Gardabani WWTP in Georgia. The figure shows that all measured concentrations of NH_4^+ exceeded the Georgian MAC of 0.39 mg/l, while the Azerbaijan MAC value (0.5 mg/l) was exceeded only once, which demonstrates the divergence of water quality assessment due to different MAC norms. The NH_4^+ concentration reached its maximum in April, during the low flow season, indicating the significant organic pollution load of the Kura river, resulting from the discharge of untreated or partially treated waste water from the main cities in Georgia. Tributaries, notably the Debed-Khrami (Armenia & Georgia) also contribute to the organic pollution.

Overall, the concentrations of BOD_5 and NH_4^+ indicate a limited impact of human activities on water quality in the Kura river basin, as most measured concentrations did not exceed the established MAC limits. Exemptions were observed for certain months during the low flow seasons. The above analysis also shows the occurrence of certain transboundary issues in water quality, caused by the releases of organic pollutants into the river from municipal and agricultural sources. Although the impact on chemical river water quality appears to be still limited, there is an urgent need for the riparian countries to develop a long-term integrated regional environmental compliance action plan aiming at reducing the pollution loads from different sources, with special focus on municipal waste water from main cities and villages located in the river basin. Meanwhile there is a lack of information on the impact of pollution loads on the biological river water quality.

Heavy Metals are metals with a high relative atomic mass, including arsenic, copper, cadmium, chromium, lead, manganese, mercury, nickel, and selenium, persisting in nature and potentially causing damage or death in animals, humans, and plants, even at concentrations as low as 1-2 micrograms. Used in industrial processes, heavy metals are carried by air and water when discharged in the environment. Since heavy metals have a propensity to accumulate in selective body organs (such as brain and liver) their prescribed average safety levels in food or water are often misleadingly high.

In the countries of the Kura Ara(k)s river basin increased attention is paid to the problem of heavy metal pollution of the aquatic environment. Mining activities, metallurgical, chemical and leather industries, as well as natural geochemical and hydro-chemical processes all pose a threat to surface water contamination with heavy metals. However, the available data on heavy metals concentration in surface water still is limited, and proper attention must be given to QA/QC procedures for laboratory analysis in order to ensure sufficient accuracy and reliability of heavy metal monitoring data in the three countries. Therefore, at this stage, the analysis of the actual situation in the Kura river basin is limited to only two metals: copper (Cu) and zinc (Zn).

The figures 4.10 and 4.11 present Cu and Zn concentrations measured at transboundary stations in the Kura river basin as collected by the EU Kura II project. Figure 4.10 shows that Cu concentrations in the Debed and Khrami rivers are almost identical, suggesting that the Cu content is determined by natural river characteristics, and not the result of anthropogenic pollution. It can also be noted from both figures that the Cu and Zn concentration at Shikhli, downstream of the Georgia-Azerbaijan border, follows the same trend as observed at the Khrami-Red Bridge station.

Figure 4.12 presents the average annual concentrations of Cu and Zn for 4 monitoring stations along the Debed river in Armenia. It shows that the measured concentrations vary from 0.002 and 0.0038 mg/l for Cu and Zn respectively in Hnkoyan Village in the upper catchment, to 0.0156 and 0.0225 mg/l for Cu and Zn near the Armenia-Georgia border, values mainly attributed to mining activities in the city of Akhatala.

Figure 4.10 Total Cu at transboundary locations in the Kura river basin in 2009.

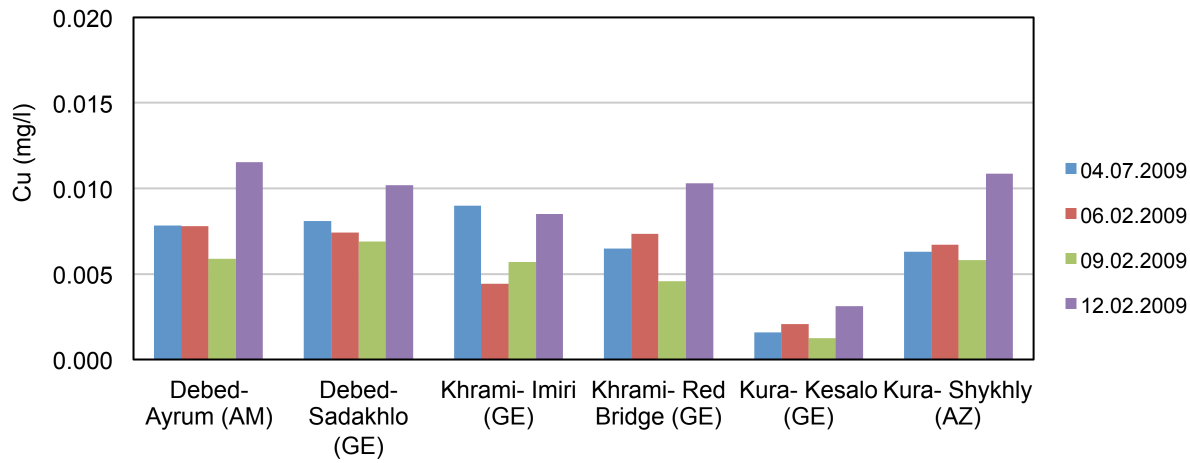


Figure 4.11 Total Zn at transboundary locations in the Kura river basin in 2010.

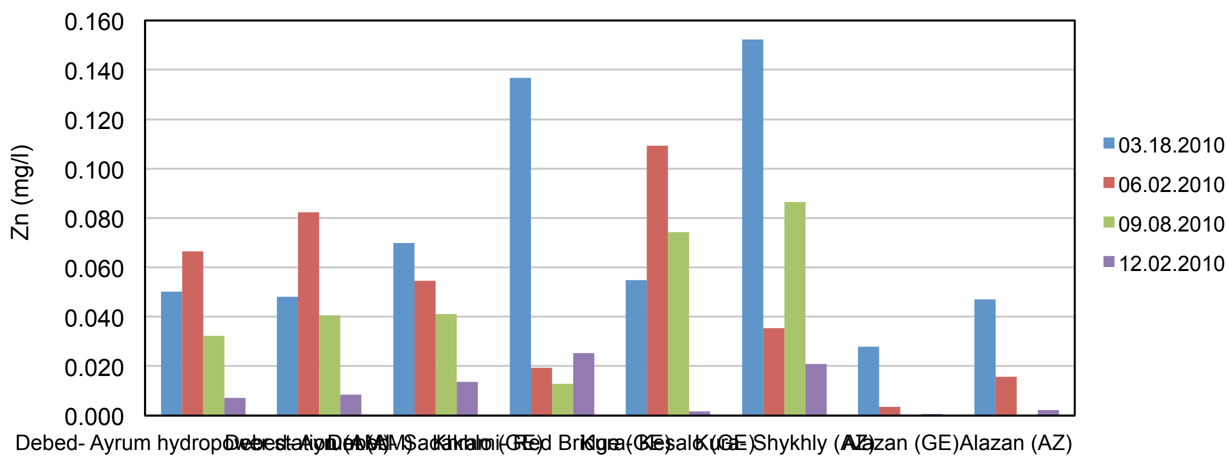
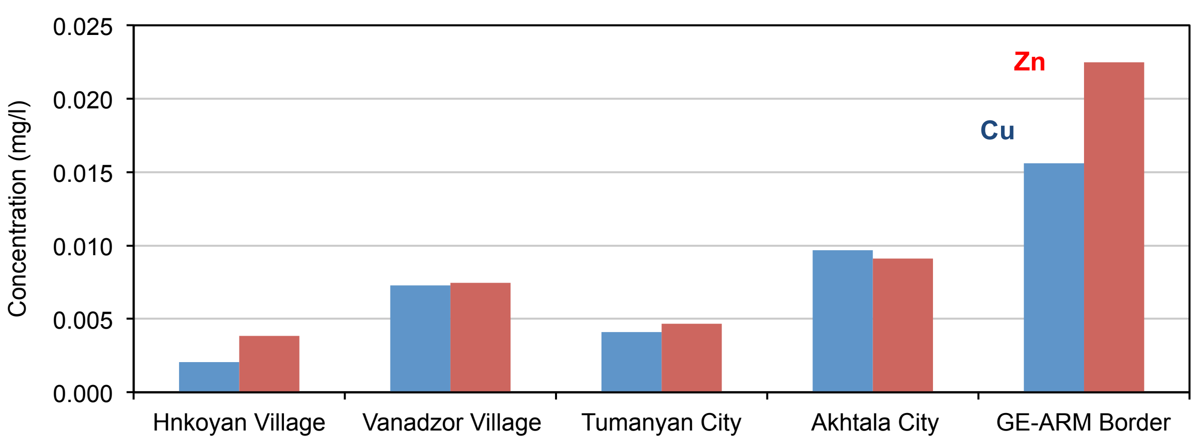


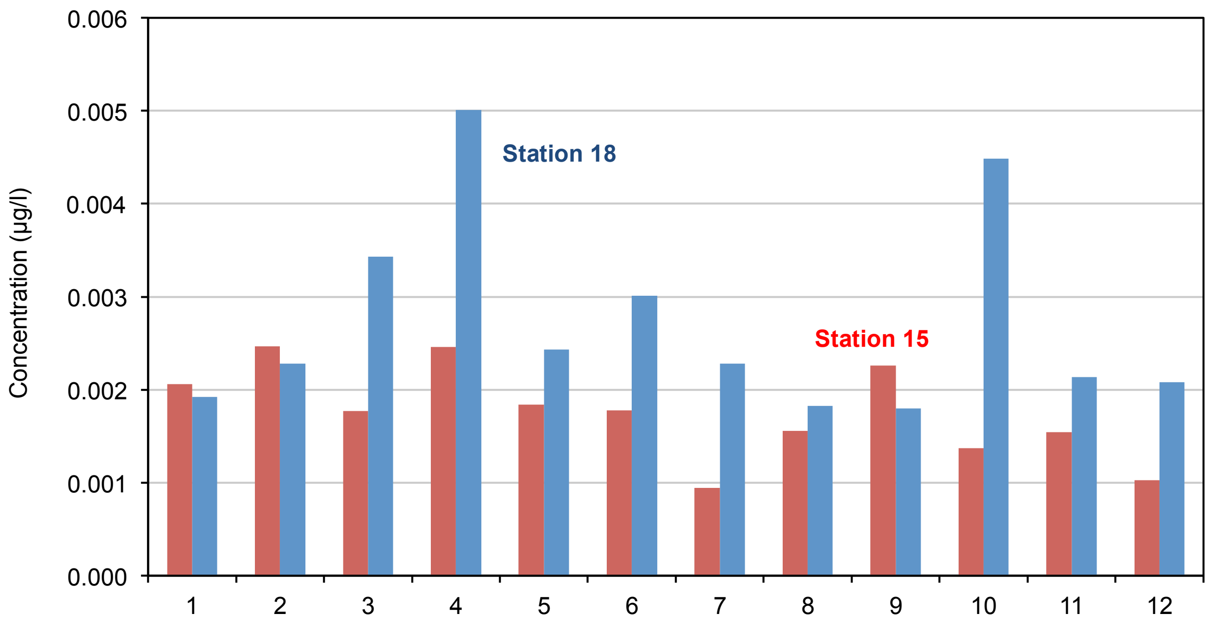
Figure 4.12 Average annual concentration of Cu and Zn in the Debed river.



Note: Based on monthly measured concentrations during the period 2008-2011.

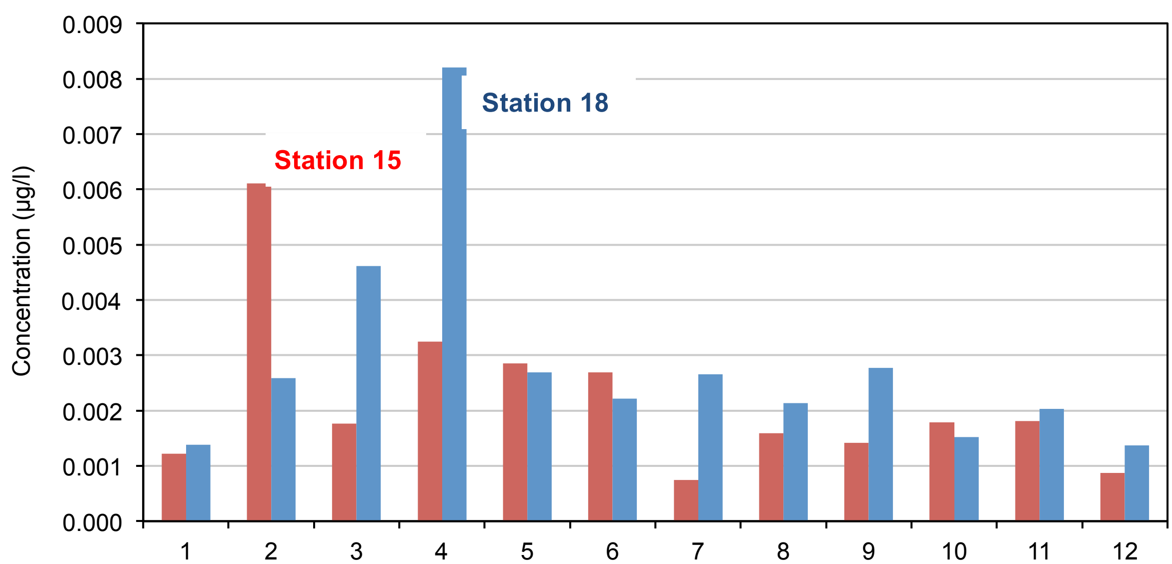
The figures 4.13 and 4.14 show the average monthly concentration of Cu and Zn for 2 stations along the Aghstev river in Armenia. Station 15 is located in the upstream section of the river, about 1.2 km upstream of Dilijan, while station 18 is located near the Armenia-Azerbaijan border, 9 km downstream of Idjevan. Both figures show a systematic slight increase of concentrations from the upstream to the downstream section in most months, indicating concentrations increase due to natural characteristics of the river, while the anthropogenic impact is minimal. Peaks for Cu in spring and autumn can be explained by rain carrying traces from soils in the catchment, combined with increased transportation of sediments.

Figure 4.13 Average monthly Cu concentration for two stations in the Aghstev river (Armenia).



Note: Based on data collected from period 2008-2011.

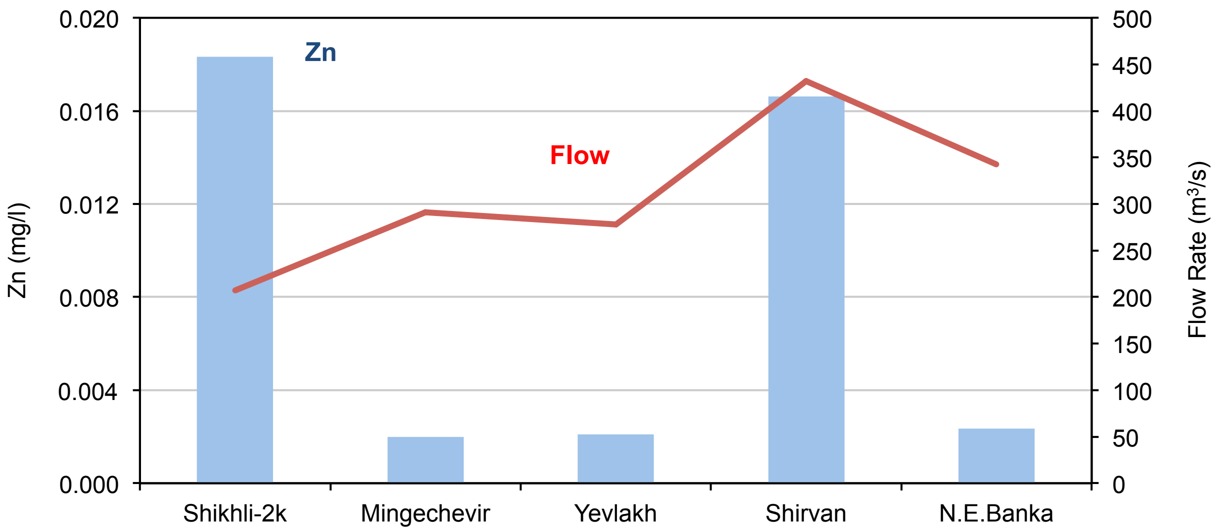
Figure 4.14 Monthly average concentration of Zn in two stations in the Aghstev river (Armenia).



Note: Based on data collected from period 2008-2011.

Figure 4.15 presents the average annual concentrations of Zn as observed at monitoring stations in Azerbaijan. A transboundary impact is clearly visible for Shikhli, downstream of the border with Georgia. Also the Mingechevir reservoir's impact on trapping the Zn load can be observed, as concentrations downstream the reservoir are much lower than those in the upstream area. However, due to the local sources and the contribution of the Ara(k)s river, Zn concentrations increase again in Shirvan, to reach a maximum of 0.0166 mg/l. Further downstream the Zn concentrations decrease sharply in N.E. Banka, to 0.00235 mg/l. High concentrations in Shikhli are due to transboundary loads from anthropogenic activities in Georgia, including releases from the Khrami river, while the high concentrations in Shirvan station are due to local sources upstream of the station as well as the contribution from the Ara(k)s River.

Figure 4.15 Average annual concentration of Zn in the Kura river in Azerbaijan.

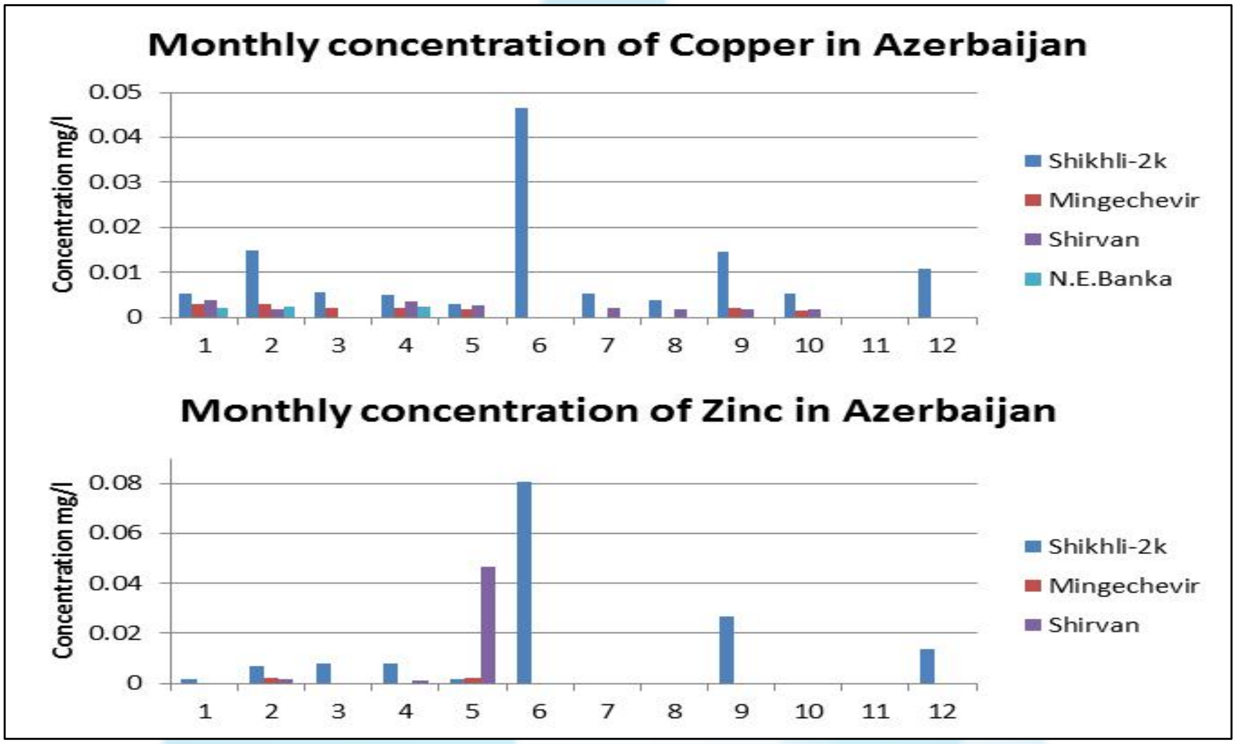


Note: Based on data collected during the period 2007-2011.

Figure 4.16 presents average monthly concentrations of Cu and Zn along the Kura River in Azerbaijan for the period 2007-2011. Both figures show some high peaks in May/June, which may be attributed to instrument error or an unusual event having occurred in those month. Accordingly, information on heavy metals from Azerbaijan needs to be rechecked to explain this nonsystematic trend in the monthly data. This raises the issue of data validation and the importance of applying statistical tests to monitoring data, to ensure their reliability and accuracy before releasing them for use in decision making.

Phenol. Figure 4.17 shows that the concentration of phenol in the Kura river at Shikhli, downstream of the border between Georgia and Azerbaijan, exceeds the Azerbaijan and Georgia MAC limits (0.001 mg/l) at least 2-fold, hinting at the high level of pollution coming from Georgia, and possibly attributed to industrial discharges from the Rustavi industrial area, located about 20 km upstream of Georgia's border with Azerbaijan. The concentration of phenol reduces after the Mingechevir reservoir, possibly due to less anthropogenic activities in this river stretch. Further downstream the phenol concentrations slightly increase at Shirvan, indicating the impacts from high population numbers and the lack of sanitation services in the cities of Shirvan, Salyan and others. Additionally also the Ara(k)s river can have contributed to the increase in phenol concentrations.

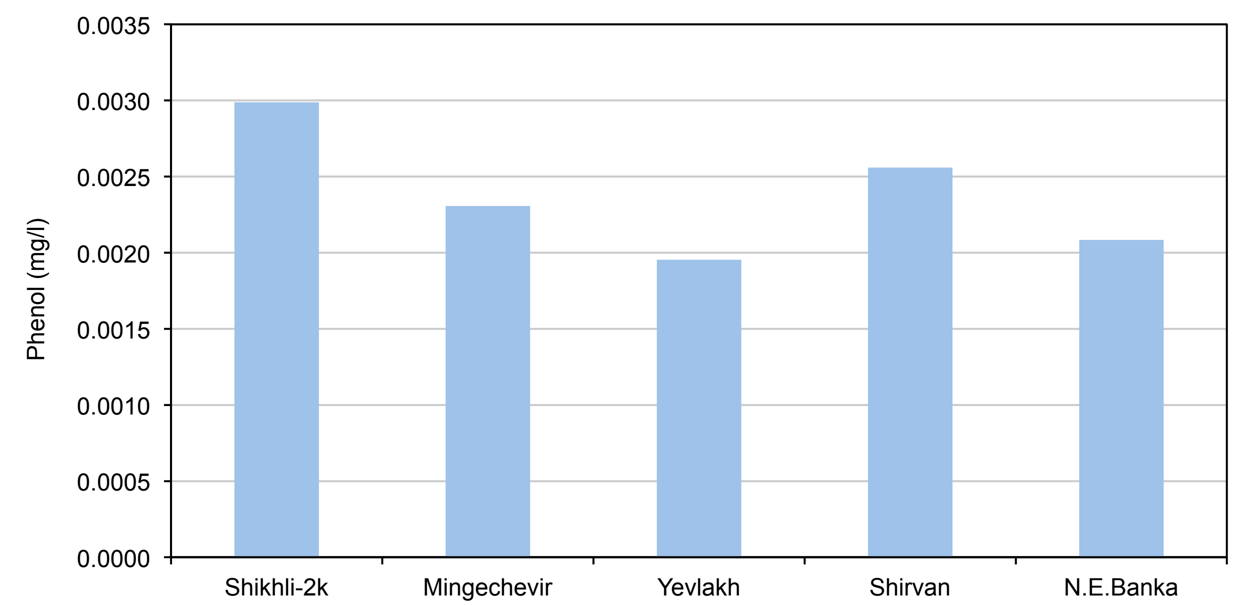
Figure 4.16 Average monthly concentration of Cu and Zn along the Kura River in Azerbaijan.



Note: Based on monthly collected data for the period 2007-2011.

Based on the five-year averaged monitoring data (2008-2012) from N.E. Banka, the average annual concentrations of oil and oil grease exceed the MAC limit by 1.2 times, as result of industrial activities, especially the petroleum sector.

Figure 4.17 Average annual concentration of phenol in the Kura river in Azerbaijan.



Note: Based on data collected during the period 2007-2011.

4.2 The Ara(k)s river basin

To analyze the surface water quality in the Ara(k)s river basin, monitoring data from 9 monitoring stations were used, of which 7 are located in Armenia and 2 in Azerbaijan. The data cover the period 2008-2010.

DO. Data for 2009 show that the concentration of DO throughout the Ara(k)s basin is high, exceeding 6.5 mg/l (figure 4.18). It shows that the DO concentrations are higher in the upper catchment area, reaching a maximum of 12 mg/l at Surmalu. A sharp decrease is observed at the outflow of Hrazdan tributary, related to its high organic load from untreated sewage water from Yerevan and its surrounding area, depleting the DO concentrations. Due to the hydro-morphological characteristics of the Ara(k)s river and relative high flow velocities in its middle reach, the DO recovered due to natural aeration, reaching about 10 mg/l at the Armenia-Iran border. In its lower reaches the DO concentrations decreases to less than 7 mg/l, largely linked to the changes in hydro-morphological features of the river from a (semi)mountainous to lowland river with reduced slopes and low flow velocities, both of which reduce the natural aeration process. Overall, the average annual concentrations of DO are considered satisfactory in the whole Ara(k)s river.

The observed pH values are normal and typical for (semi)mountainous rivers in all monitoring stations.

TDS. The average annual concentrations of TDS along the Ara(k)s River for 2008-2010 are presented in figure 4.19. It is shown that at the river's source and in the upstream catchment of the Akhuryan tributary, the TDS is low, 100-300 mg/l (station 25). At the mouth of the Hrazdan tributary (station 27), on the Armenian-Turkish border, the TDS increased almost 2-fold, but the water is still low-mineralized. The TDS values at the exit of the Ara(k)s river from Armenia to Turkey (station 28) are low and practically coincide with the values at the mouth of the Hrazdan River.

Figure 4.18 Average annual concentration of DO in the Ara(k)s river (year 2009).

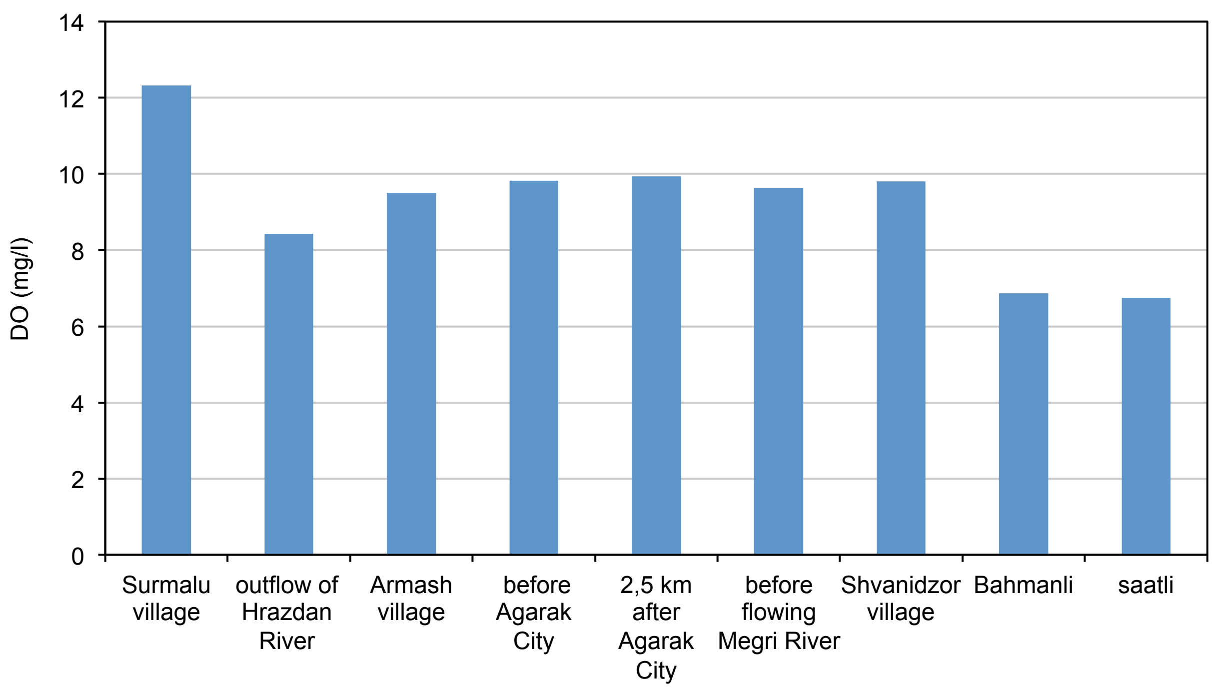
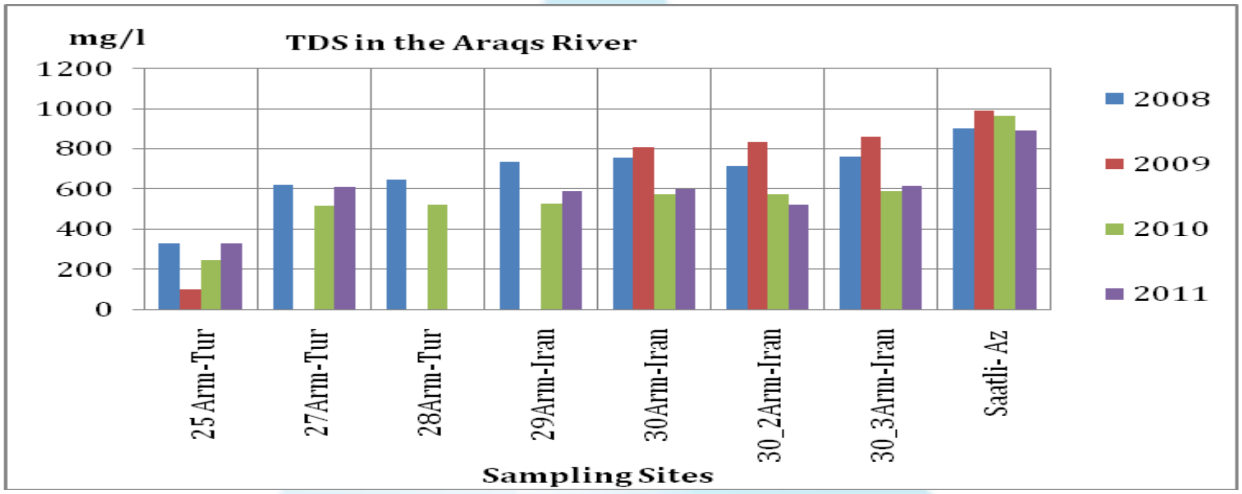


Figure 4.19 Average annual TDS along the Ara(k)s River for the period 2008-2011.



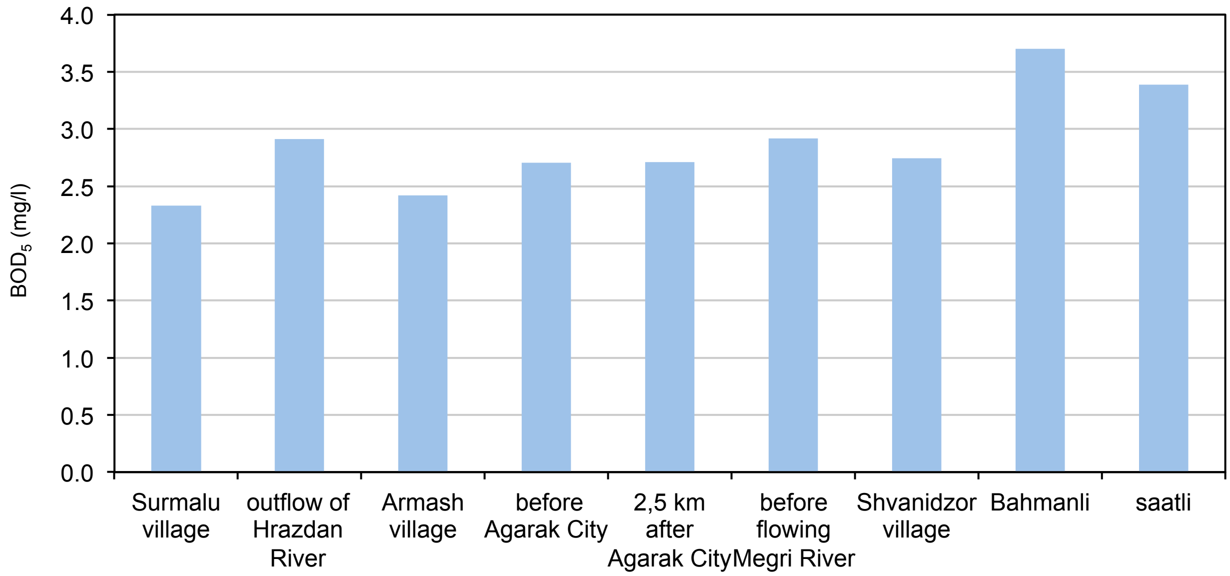
Note: Site 25 - entry point Armenian-Turkish border; 27 - below the outflow of Hrazdan river; 28 - exit point Armenian-Turkish border; 29 - entry point Armenian-Iranian border; 30 - below the outflow of Karchevan river (after tailing dam Agarak mining factory), Armenian-Iranian border; 30-2 - before confluence of Meghri river, Armenian-Iranian border; 30-3 - exit point Armenian-Iranian border; Saatli-Az - mouth of the Ara(k)s river.

Downstream, in the Ararat Valley, TDS values in Ara(k)s river water increase to 500-600 mg/l, indicating the impacts of anthropogenic activities in the basin, in particular the contribution of untreated/ partially treated sewage waste from urban areas, as well as from agricultural drainage water. At point 29 the river forms the Armenian-Iranian border, 2 km before Agarak City. For all the three stations at the Armenian-Iranian border the TDS is rather high - 600-800 mg/l. At the confluence with the Kura river at Saatli in Azerbaijan, the TDS reaches 900-1,000 mg/l, most likely due to natural hydro-chemical conditions that increase the sedimentation load to the river during the flooding period and the leaching of soil contamination. Addition factors include the anthropogenic impact from agriculture drainage water and point source discharges of untreated sewage. It is concluded that the water quality in this basin is rather good in the upper reach, while being classified as medium saline in its middle and lower parts.

BOD_5. Figure 4.20 presents the average annual concentration of BOD_5 in the Ara(k)s river between Surmalu in the upper catchment of the river to Saatli in Azerbaijan. It shows that at the entry point on the Turkey-Armenia border the BOD_5 varies between 1.8-2.8 mg/l with an average value of 2.33 mg/l. The highest concentration was measured the downstream of the outflow of the Hrazdan river, indicating at pollution with organic substances coming from Hrazdan river to the Ara(k)s river.

Increased concentrations of organic matter in the Ara(k)s river have several sources in Armenia: agricultural drainage water; waste water from poorly functioning WWTP, if existing at all; unlined landfills and illegal waste dumps of rural households; and livestock farming. All these activities occur in the most densely populated region of Armenia, the Ararat valley, providing 80% of all waste generated in Armenia (excluding mining wastes). An important source of pollution of the Ara(k)s river is water contributed by the Hrazdan tributary, contaminated with municipal wastewater from Yerevan as well as by agricultural drainage water. On the other hand, in the Armenian mountain tributaries to the Ara(k)s, e.g. the upper and middle reaches of the Hrazdan, Arpa, and Azat rivers the nutrient content is rather low, and water can be characterized as oligotrophic, while the water quality in the lower reaches of the Hrazdan river is eutrophic, which directly affect the water quality in the Ara(k)s downstream the outflow of Hrazdan river.

Figure 4.20 Average annual concentration of BOD_5 along the Ara(k)s river.



Note: Based on data collected during the period 2008-2011.

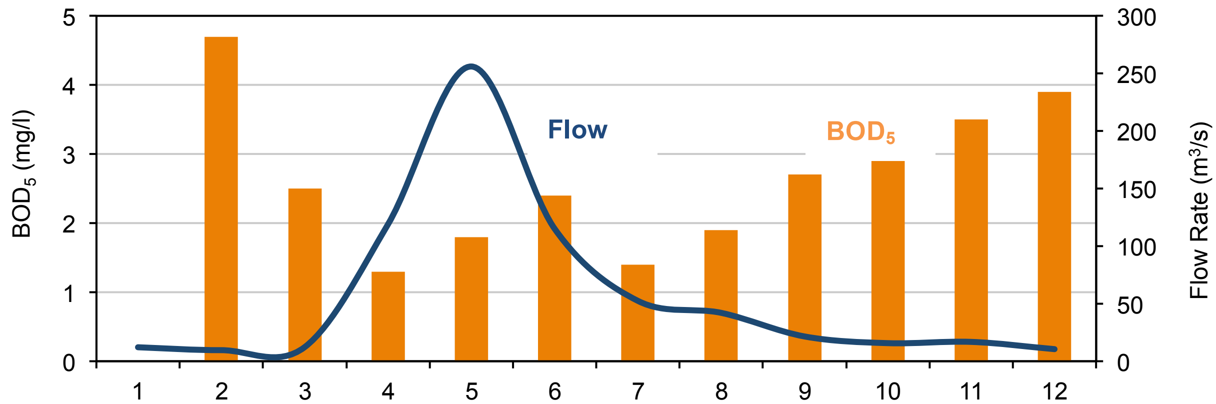
In Turkey, sources of organic pollution to the Ara(k)s river include: agricultural drainage water, sewage and household water from municipal sewer systems, leakage water from city landfills, unorganized waste dumps of rural households; and livestock farming. However, BOD_5 values along the river remain close to 3 mg/l. This indicates that the combination of hydrological regime and hydro-morphological conditions in the middle reaches of the river creates conditions for the rapid oxidation of organic matter, limiting an increase in BOD_5 values. As such also the transboundary significance of organic pollution seems to be limited.

BOD_5 values at the Armenian-Iranian border, starting from Agarak, indicate that the Ara(k)s river is polluted with organic substances somewhere along the Azerbaijan-Turkey or Azerbaijan-Iran border. As the river banks, both on the Azerbaijan and Iranian sides, are not industrialized, the sources of pollution probably include municipal sewage, agricultural drainage water, waste water from landfills, and rural households.

Overall the BOD_5 concentration along the Ara(k)s river shows an increasing trend from the upstream to the downstream area, coming close to the MAC limit of 3 mg/l in almost all sites. This is considered high for a mountainous river, and as such an indication of a high organic pollution load received by the river from the anthropogenic activities. In its downstream stretches in Azerbaijan the hydro-morphologic characteristics of the river changes towards lesser slopes and lower water velocities. These features reduce the natural aeration process and cause an increase in BOD_5 concentrations to be observed at Bahmanli and Saatli.

Figure 4.21 presents the seasonal relationship between BOD_5 and the flow rate for the station before the outflow of the Meghri tributary, at the Armenia-Iran border. It shows the inverse relation between BOD_5 concentration and flow, caused by higher flow rates improving the water aeration processes to replenish the DO content, which favors a better oxidation of the organic load and reduces BOD_5. Increased flow volumes also dilute the pollution load, further decreasing the concentration of the any pollutant.

Figure 4.21 Monthly variations of BOD_5 and flow rates at the Ara(k)s river in southern Armenia.

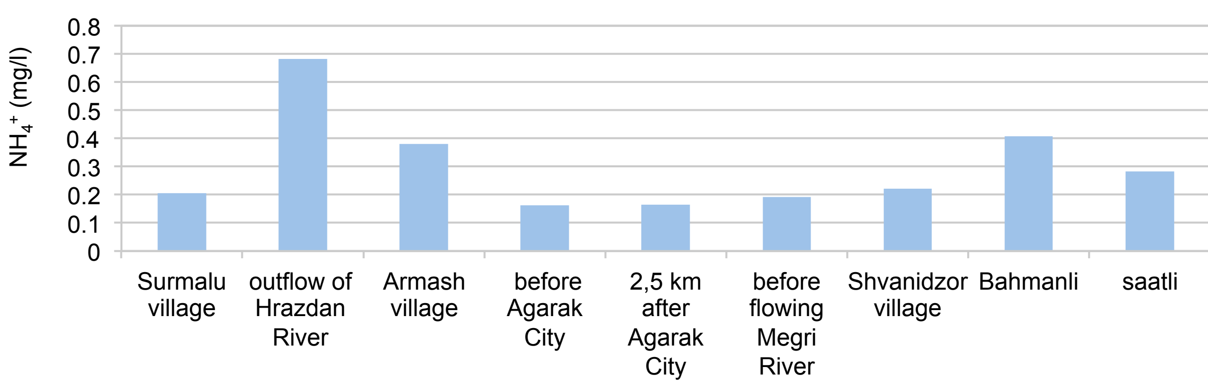


Ammonium Figure 4.22 shows that the values of NH_4^+ along the Ara(k)s river are below the MAC of 0.4 mg/l, except for the outflow of Hrazdan tributary in Armenia and Bahmanli in Azerbaijan. Downstream of the outflow of the Hrazdan tributary, the NH_4^+ concentration exceeds the MAC by 1.7 times to reach on average 6.8 mg/l, a result of the significant outflow of municipal waste water from the Yerevan WWTP into the Hrazdan river without chemical and biological treatment applied. At the mouth of the Hrazdan river the average annual concentration of NH_4^+ in 2009 and 2010 was 4.5 and 5.7 mg/l respectively. Other NH_4^+ pollution sources in this area include agricultural drainage water, leachate water from landfills, and illegal accumulations of rural household wastes.

After the Hrazdan river the NH_4^+ concentration rapidly decreases, and within 30-40 km - at Armash - reaches 3.8 mg/l, indicating the river's natural self-cleaning capacity due to its specific hydrological regime and hydro-morphologic features. Further downstream NH_4^+ remains below the MAC, ranging between 0.1616 and 0.221 mg/l at Shavindzor, the last station before the Azerbaijan border. Overall, however, the observed concentrations are high for a mountainous river.

In Azerbaijan increased concentrations of NH_4^+ are observed, reaching 0.407 mg/l at Bahmanli, indicating a high organic load. The presence of wetlands and the low flow velocities reduce DO and increase NH_4^+ and BOD_5. More study is needed to differentiate between contributions from transboundary sources and local sources, taking into account that NH_4^+ at the Armenia-Iran border indicated a limited pollution load, offset by processes of self-purification, while the population density in this part of the Ara(k)s basin is low, and hence the municipal and agricultural pressures on river water quality are is low as well.

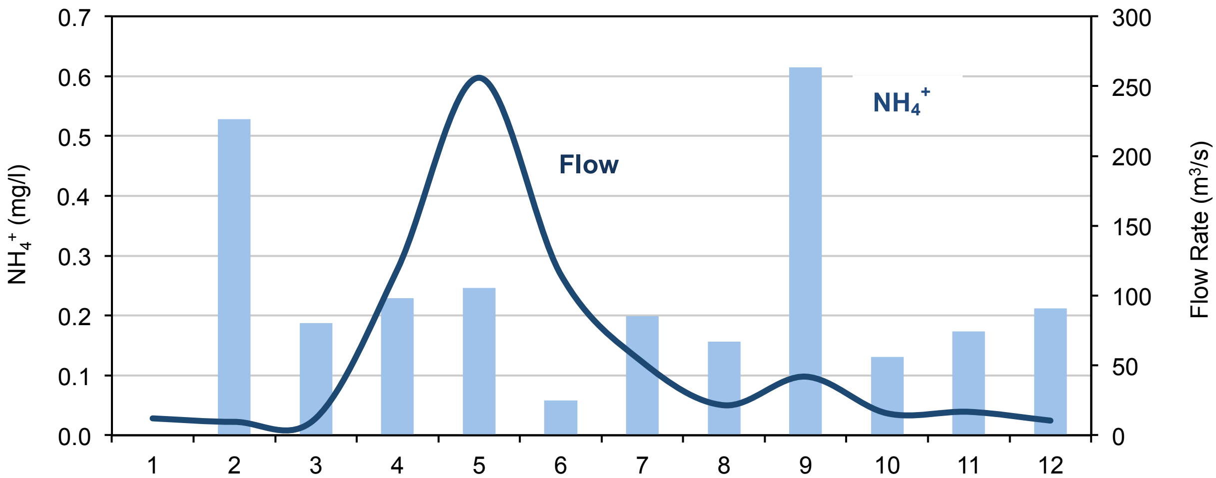
Figure 4.22 Average annual concentrations of NH_4^+ along the Ara(k)s River.



Note: Based on data collected during the period 2008-2011.

Figure 4.23 shows the seasonal variation of NH_4^+ concentration and the flow rate in the Ara(k)s river for the station before the outflow of the Meghri tributary, at the Armenia-Iran border. It shows that during low flow months the Ara(k)s river experiences a very high level of NH_4^+, reaching 0.614 mg/l in September, or 1.57 times higher than the MAC. High concentrations in low flow months indicate the high organic load in the Ara(k)s river water at this stretch, which is diluted naturally during the flooding period and related high rates of flow in the river, while also natural self-cleaning takes place. During the low flow season, the significantly lower volume of water increases the concentration of organic pollutants, while also self-purification is less significant due to lower oxygen availability.

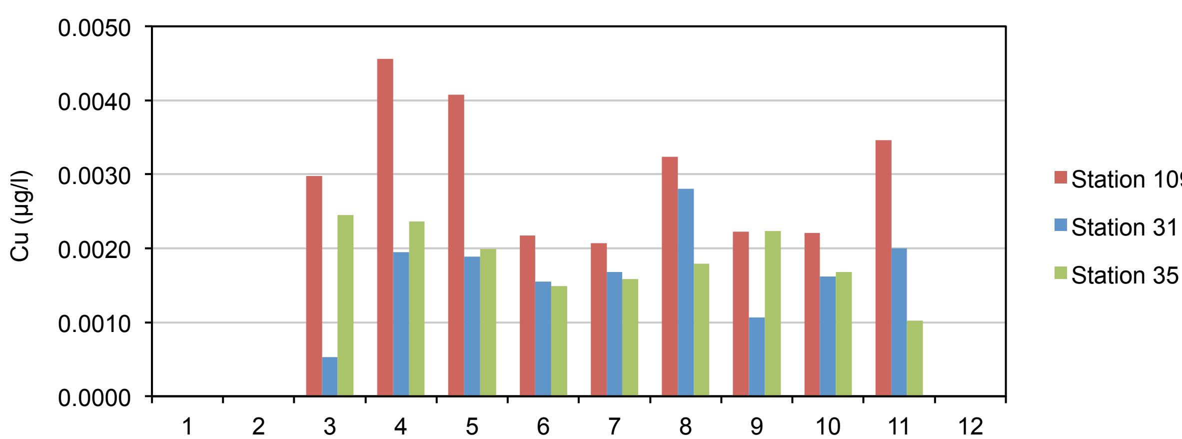
Figure 4.23 Relationship between NH_4^+ and flow rate in the Ara(k)s river near Meghri.



Note: Based on data collected during the period 2008-2011.

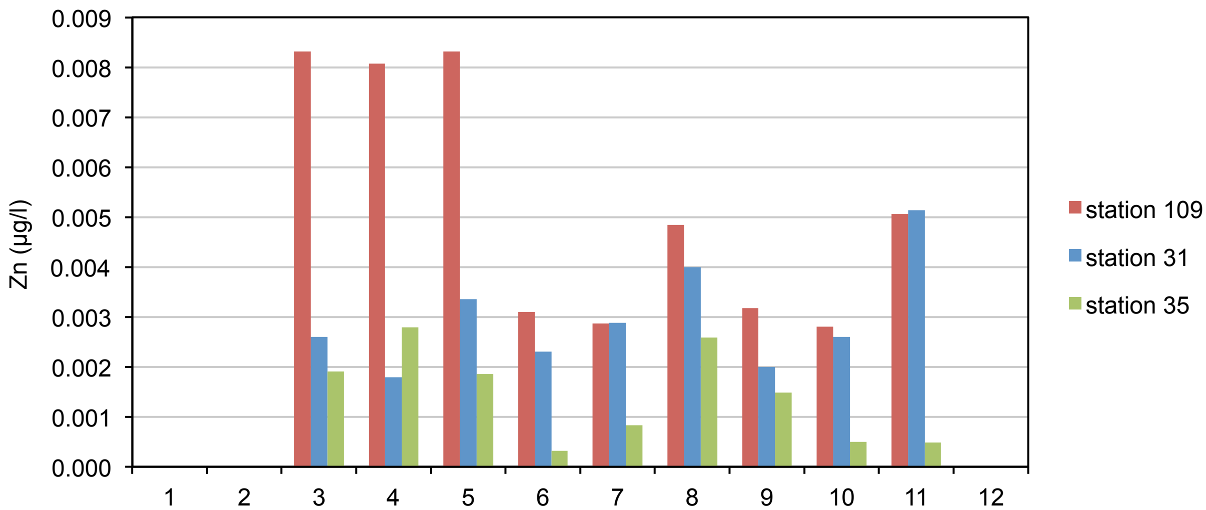
Heavy Metals (Cu, Zn). The figures 4.24 and 4.25 present the average monthly concentrations of Cu and Zn in the Akhuryan river, showing comparable trends –higher concentrations in the upper reaches near its intake from Lake Tseli, to gradually reduce to minimum values between the intake and the outflow of the river into the Ara(k)s river. This trend is constant in all months of the year, indicating there are no sources of heavy metals along the Akhuryan river in both Armenia and Turkey. The average concentrations of Cu and Zn are low and typical for upper reaches of mountainous rivers in Armenia.

Figure 4.24 Average monthly concentration of Cu in the Akhuryan river.



Note: Based on data collected during the period 2008-2011.

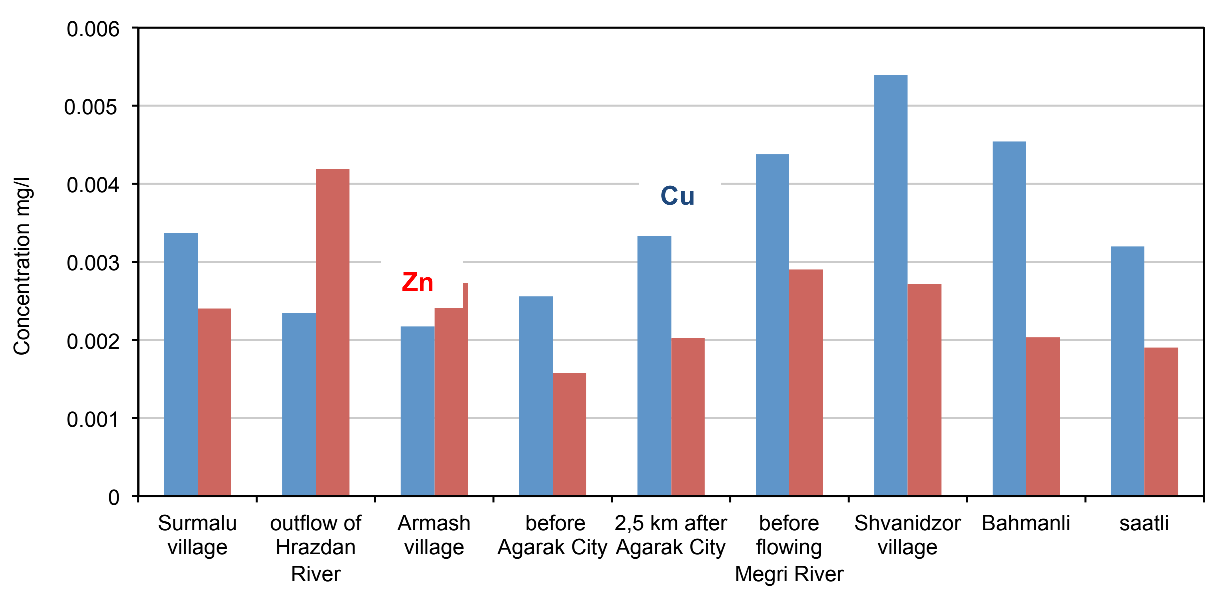
Figure 4.25 Average monthly concentration of Zn in the Akhuryan river.



Note: Based on data collected during the period 2008-2011.

In figure 4.26 the average annual concentrations for Cu and Zn are presented for 9 monitoring stations along the Ara(k)s river. Until the Armenia-Iran at Agarak, the Cu concentration remains almost unchanged compared to the upper reaches, suggesting the absence of pollution sources between the Turkey-Armenia border and the Armenia-Iran border. Going downstream from Agarak towards Shvaindzor, the Cu concentration almost doubles, assumed to be the result of the operations of the Agarak Copper-Molybdenum Industrial Factory in the Armenian part of the basin. Increasing Cu concentrations due to mining activities in Armenia contribute to the relatively high concentration of Cu in Bahmanli (Azerbaijan). Towards Saatli the Cu concentration decreases, indicating the absence of local sources of pollution along the Azerbaijan section of the Aras river downstream of Bahmanli, indicating that the observed concentrations of Cu are due to transboundary impact from Shvanidzor village.

Figure 4.26 Average annual concentration of Cu and Zn along the Ara(k)s river.



Note: Based on monitoring data collected during the period 2008-2011.

The increased Zn concentrations in the Ara(k)s river downstream of the Hrazdan tributary suggests a source of Zn either between Surmalu and the Hrazdan river on the Ara(k)s river, or along the Hrazdan river. Insufficient data are available to identify the source of this high Zn concentration. Further downstream the Zn concentrations decrease until Agarak, after which a slight increase is observed, although still much lower than the MAC. As with Cu, the highest concentrations of Zn occur between the Megri outflow and Shvanidzor village, due to mining activities. Lower concentrations in downstream direction indicate the source of pollution coming from this village. After Bahmanli the Zn concentration reduces further towards the Saatli station, indicating that there are no local sources of Zn pollution between these two stations in Azerbaijan, and the concentrations of Zn are due to transboundary impact from Shvanidzor village.

Overall, the measured concentrations of Cu and Zn in the Ara(k)s river are low, except at Shvanidzor village in Armenia, where relatively high concentrations of Cu, reaching 0.0054 mg/l were observed. Therefore there is a potential for downstream transboundary impacts from mining activities in Agarak and Shvanidzor village.

4.3 Pressures on water resources in the Alazani/Ganikh river basin.

In the Alazani/Ganikh river basin, water resources are used for domestic consumption, irrigation, electricity generation as well as industrial purposes. In accordance with the 2009 data of the Georgian Ministry of Environmental Protection and Natural Resources, in total 724.81 mln m^3 water was abstracted from water bodies in the basin, of which 12.36 mln m^3 (1.7%) was abstracted from groundwater sources and 712.45 mln m^3 (98.3%) – from surface water sources. The largest amount of abstracted water - 629.24 mln m^3 - was used for electricity generation, 9.95 mln m^3 – for domestic consumption, and 5.87 mln m^3 – for irrigation. Analyses of the current information on water use show that the highest pressures on water in the Alazani/Ganikh basin occur in the upstream areas. Water from the Alazani/Ganikh are the most utilized, followed by water from the Samkuristskali tributary, while the Bursa and Lopota tributaries are also highly utilized. The hydropower sector is the largest water consumer, receiving water from direct abstractions as well as through the transfer from irrigation systems.

In 2009, in total 646 mln m^3 waste water was discharged into water bodies of the Alazani/Ganikh river basin, of which 629.21 mln m^3 was clean water discharged by the hydropower sector and 11.58 mln m^3 – untreated waste water. The major point sources of pollution in the Alazani/Ganikh basin are domestic sewerage systems. Industrial wastewater discharges at present are significantly lower compared to the Soviet period, due the significantly reduced number of enterprises, which typically operate at much lower capacities. However, the present-day absence or the obsolescence of wastewater treatment facilities and technologies might offset the situation. Among diffused sources of pollution, the most significant ones include agriculture, urban run-off and leachates from waste disposal sites. Abandoned warehouses containing obsolete pesticide stock-piles were one of the significant non-point sources of pollution until recently. Although all obsolete pesticides were collected and moved to a temporary storage facility outside the Kakheti region, the areas surrounding the former storehouses might be still contaminated with POPs. In addition, open-pit mining operations for the extraction of non-metal mineral resources also pose a threat to the waters and ecosystems of the basin.

4.4 Pressures on water resources of the Iori river basin.

In the Iori Basin, according to the 2009 official data of the Georgian Ministry of Environmental Protection and Natural Resources, water withdrawals were made from the Iori river and the Sioni reservoir. In total, 260.95 mln m^3 was abstracted from natural water bodies, of which 179.68 mln m^3 was taken from the Iori river, 2.1 mln m^3 – from Iori filtrates, and 78.85 mln m^3 – from the Sioni reservoir. Surface water was abstracted to be fed into the Upper and Lower Samgori irrigation canals. Out of the total amount, only 1.92 mln m^3 was used for irrigation purposes, while the rest was transferred to the hydropower plants

(HPPs). Water taken from the Sioni reservoir was used by the Sioni HPP. Analyses of the current information on water use show that in the Iori basin the major pressure on water resources was created by HPPs and irrigation systems.

According to the 2009 official data of the Georgian Ministry of Environmental Protection and Natural Resources, a total of 65.74 mln m^3 wastewater was discharged, of which 65.57 mln m^3 was discharged into surface waters and 0.17 mln m^3 – to the surface relief. In total 64.77 mln m^3 wastewater was discharged by the "Sioni-M" irrigation company into both the Iori river and the Samgori reservoir without any consumption through a transit system. The total amount of untreated sewage water discharged from centralized sewerage systems amounted to 0.9 mln m^3, of industrial wastewaters – 0.08 mln m^3, of which only 0.004 mln m^3 was mechanically treated. Wastewater discharges occurred mostly in the Tianeti and Sagarejo districts. Regarding the quality of wastewater, no effluent monitoring is being undertaken in the country. In accordance with estimates by the Georgian Ministry of Environmental Protection, the river's ecological and chemical status is assessed as "good". Azerbaijan confirms that there is little human impact on the river.

In the Alazani and Iori river basins, ecosystems and their resources, including water and associated resources have the following functions:

- Health protection: to provide drinking water, nutritional base, energy and clean environment to population.
- Economic (commercial): to provide water and other resources for agriculture, industries, fisheries and power generation.
- Livelihood support: to provide resources – fire wood, timber and woodchips as construction materials, mushrooms, berries, medicinal plants, pastures, etc. - for local subsistence economies.
- Ecological: to maintain the ecosystem integrity, richness and health.
- Disaster Risk Reduction: to prevent floods, landslides, mudflows and avalanches, and reduce their impacts.
- Aesthetic: to provide recreational resources to the population.
- The importance of these functions varies between upstream and downstream areas, as well as between the Alazani and Iori river basins.

Ecosystems of the upstream areas of both the Alazani and Iori river basins have more value in supporting biodiversity, maintaining ecosystem integrity, providing high quality recreational resources and supporting the subsistence economies of local communities, compared to their direct commercial value. Degradation of these natural ecosystems will ultimately result in increased natural disasters, reduced water resources, loss of biodiversity and, reduced aesthetic value leading to decreased tourists flow.

5. MAJOR SOURCES OF WATER POLLUTION

This section elaborates on the sources of water pollution in each riparian country and the contribution of each source to the overall water quality status. It will also highlight the main pollutant substances that are released by each sector and the impact on the water quality in the river basin.

Pollution in the Kura river includes organic pollution from untreated sewage, heavy metals from mining, hydrocarbons and PCBs from industry, nutrients and organo-chlorine pesticides from agriculture, and high sediment loads from deforestation and flood irrigation practices. Cities and industrial centers are the main sources of pollution, with low capacity of WWTP or their absence in general. Where present, facilities have not been updated or maintained since 1992, and are outdated and in disrepair. Effectively, the treatment capacity of the working WWTPs does not exceed 20% of the water volume in need of treatment. Accordingly, large quantities of water are discharged into the Kura river untreated. With a population of 11 million this leaves a discharge load of 8.5 million inhabitant equivalent of organic pollution, of which more than 35% is concentrated around Yerevan and Tbilisi. For example, sewerage collecting systems exist in about 40 towns in Georgia, but only 70% of the urban population is connected. In rural areas, the connection rate is much lower. Currently, only one WWTP - of Tbilisi/Rustavi, managed by a private company - is in operation, but applying mechanical treatment only. Per year 300 mln m^3 of wastewater are discharged, of which 74% is treated mechanically.

Also some industrial sectors such as mining, oil production or food production & processing strongly affect surface water quality. A permit is not required in cases of wastewater discharge. Food production impacts on water quality through high loadings of nutrients and organic material, the mining industry through heavy metals and suspended material. The lack of monitoring and control of industrial discharges into public sewerage systems led to the deterioration of the public systems and worsened water pollution. Agreements with the industries state that each facility must carry out wastewater pre-treatment to meet MACs requirements before discharge into the public sewerage network. However, as no regulations exist for indirect discharges, most industrial facilities do not operate pre-treatment units, but dump their industrial wastewater into the sewerage system, without attention paid on whether or not MACs are exceeded, as such damaging components of the sewage network and reducing the efficiency of WWTPs.

The Georgian Ministry of Environmental Protection signed memorandums with major enterprises aimed at implementing environmental compliance programs. A memorandum lists environmental activities planned by the enterprise, a timetable and the procedure required for obtaining the Environmental Impact Permit.

The Armenia National Water Program includes a 30-year action plan to re-build all WWTPs, requiring cooperation with international donors to provide financial and technical implementation support.

The Azerbaijan Government is implementing the state policy on supplying citizens with fresh water. Under this policy, permanent and portable municipal water treatment plants were constructed in large urban areas. At the same time, wastewater treatment as well as solid waste recycling occurs only in large urban areas. As such, inhabitants of smaller towns and villages pollute the river water, due to the lack of sanitation services.

During the last 2 decades the riparian countries discharged less industrial waste than during the Soviet era, as many factories either were closed – including large chemical industries - or operate at limited capacity, and as such the contribution to the water pollution is insignificant. Despite the diminishing volumes of the Armenian mining industry, mine waste storages are still remaining. During rains and floods, water penetrates into these storages, gets polluted and flows to Azerbaijan through the Ara(k)s river. However, the mining industry is recently developing again, especially in Armenia. According to surface water quality monitoring, the level of pollution by heavy metals is higher in some rivers, such as Debed and Voghji, caused by effluent discharge from the Akhatala ore mining plant and the Copper-Molybdenum plant in Kajaran, respectively.

6. IDENTIFICATION OF MAIN HOT-SPOTS

Analytical work executed in preparation of this Desk Study showed that the frequency and distribution of monitoring are insufficient to identify the origin and extent of pollution point sources or 'hot spots', although available information provides an indication of the long-term trends in water quality. The Kura throughout of its catchment is the recipient of a wide range of municipal and industrial waste flows. In addition, diffuse pollutant sources including leachates from former landfill and industrial sites introduce a wide range of contaminants to the river. A significant proportion of the pollution inflow occurs downstream of the Tbilisi metropolitan area. It is widely acknowledged that municipal wastewater constitutes the major pollutant input to the Kura, due to the absence of secondary treatment capacity in the region.

Meanwhile, hydro-biological monitoring of surface water quality is not yet institutionalized, although some data have been collected by the EU Kura River Phase II and Phase III projects. However, the available data are insufficient to establish reference conditions and to develop ecological quality ratios, required to classify water bodies according to their ecological status. At the same time historical data are absent. Expanding existing data sets to fulfill this requirement likely will take up to three years. Also the analytical capacity may limit the number of parameters to be included in physiochemical status monitoring.

The information provided by the National Experts from the three riparian countries included for Armenia a detailed list of hotspots along both the Kura and Ara(k)s rivers and their tributaries, while the Azerbaijan and Georgia reports were rather general on the main sources of pollution. It is concluded that the most critical source of pollution emphasized by all three countries is organic pollution, providing the highest share in the Kura-Ara(k)s River basin pollution, due to the lack of WWTPs in all three countries,. The lack of monitoring data on the bacteriological pollution is one of the drawbacks of the monitoring programs in both Armenia and Azerbaijan, while in Georgia 3 microbiological indicators for bacteriological pollution are monitored. These three indicators are recommended to be also included in the national monitoring programs for both Armenia and Azerbaijan, including setting the MAC values for them in the executive regulations. The hot-spots of bacteriological pollution include the cities of Tbilisi, Gori and Rustavi in Georgia, Yerevan, Hrazdan and Vanadzor in Armenia, and Mingechevir, Yevlakh and Shirvan in Azerbaijan.

A high level of NH_4^+ is noted in the Debed river where the sewage of Vanadzor is discharged. However, after 40-50 kilometers, the NH_4^+ concentration significantly reduced, and before reaching the Georgian border, the water is in fact "treated". Thus, the organic and biological pollution of the Debed river do not have any transboundary impact on either the Khrami or Kura rivers. The Hrazdan river does not manage to self-purify its water before the confluence with the Ara(k)s river, being too short – about 20 km. Accordingly, a threat exists of biological and organic pollution of the transboundary waters of the Ara(k)s, in addition to municipal sources believed to be partly caused by agriculture and cattle in the Ararat Valley.

Research executed under the EU Kura projects stresses that due to higher population densities and the low number of WWTPs, the pollution with organic compounds is an issue for the riparian countries. However the level of pollution is within the permissible limits. As compared to the annual rates of pollution of the Danube river waters, the level of pollution does not exceed the allowable limits

Pesticides were mostly imported and used during the Soviet era, stored in special storage facilities, most of which have been removed in recent years. As of 2006, of 214 identified pesticides storage sites in Georgia, only 44 facilities with chemicals present on-site were left in the country. Residuals of toxic chemicals at these sites are mixed with the soil and are slowly been washing out, possibly affecting the quality of ground and surface waters in the river basin. In addition to abandoned pesticide storage facilities, a persisting problem is pesticide burial sites. These burial sites usually are covered with only a thin layer of soil, providing insufficient protection. Occasionally chemicals are washed out by rain, causing "visible" surface spots of pesticides mixed with soil and a strong chemical smell. Critical hotspots of POPs also include abandoned former Soviet military sites, where different POPs are stored in the open air.

7. CONCLUSIONS AND RECOMMENDATIONS

Transboundary water management is very important for the South Caucasus. Two of three riparian countries of the Kura Ara(k)s basin are for more than 70% being part of transboundary river basins, and one of the three countries has more than 50% of its water resources originating outside of its boundaries. Pressing concerns such as flood mitigation, improvement of water quality, operation of hydraulic infrastructure, and wetlands conservation, all have transboundary dimensions.

The analysis of the available data from water quality monitoring in the Kura Ara(k)s river basin shows limited evidence of transboundary pollution on an annual basis, due to the hydro-morphological characteristics of the rivers in the upstream countries. These largely mountainous rivers are characterized by higher velocities of water flow, contributing to improved aeration processes and the decrease in organic matter. However, the present document shows that in certain months, especially during the low flow seasons, the occurrence of transboundary pollution can be observed in Azerbaijan from the upstream countries, a combined consequence of the high and constant pollution load with low rate of flows in the rivers.

Some countries are making progress in managing transboundary water resources, in adopting broadly recognized principles, including responsibility for cooperation and joint management and the incorporation of transboundary water issues in revised legal and institutional frameworks. Support from the UNECE has been requested by Georgia and Azerbaijan to establish a bilateral agreement on the management of the transboundary waters between the two countries. Georgia also requested the support of the UNECE in the preparation for the ratification and the implementation of the UNECE Water Convention. In 2010, UNDP launched a cooperation project between Georgia and Armenia on fostering transboundary cooperation in the Kura Ara(k)s river basin, aiming to strengthen the dialogue between Armenia and Georgia on cooperation frameworks for transboundary water management and identification of existing transboundary water quality monitoring schemes. The project also provided support for the comparative analysis of the EU WFD approaches and water sector legislation in Armenia.

Building on initiatives for better management of transboundary water in the south Caucasian region, and based on the analysis of current water quality management in the region, the following are recommended actions to strengthen regional cooperation and capacities in transboundary water management:

- Adapt the national monitoring networks, schedule and parameters: There is a general recognition that in the context of water quality and wastewater discharges to the Kura river, suitable data of sufficient quality on which to build decisions are limited. The frequency, distribution, and location of monitored parameters are insufficient to identify the location and extent of pollution point sources or ‘hot spots’. Staff retention plan should be developed to provide incentives for well-trained staff to remain working in monitoring laboratories, to reduce the high rate of staff turnover.
- Develop pollution sources hot-spots maps: Efforts should be made to complete an emission inventory for the main sources of pollution in the Kura Ara(k)s river basin, to determine the exact location and contribution of each source to the pollution load entering the river basin.
- Address terrestrial pollution sources: The absence of lined landfill sites with leachate traps, and the practice of co-disposal of both municipal and hazardous wastes in uncontrolled landfill sites, requires that leachate monitoring should be routinely undertaken at existing and former landfill sites and illegal dumps adjacent to the rivers, where the potential for water contamination is high. An improved mechanism to record and verify industrial and municipal waste sources and flows should be put in place, and an integrated solid waste management program should be designed.
- Adopt bio-monitoring: Physico-chemical analyses give a measurement which is valid only for the instance in time when the sample was collected, whereas biological methods reflect the effects of the physical and chemical conditions to which the organisms were exposed over a period of time.

Biological monitoring is recommended to be widely introduced, including the establishment of appropriate reference conditions, to determine the ecological status of water bodies.

- Adopt comparable water quality standards: It is recommended to review and update water quality standards in all basin countries, towards designating identical norms for the main water pollutants. The model that has been adopted in Armenia can be further discussed and enhanced to be the base for developing regional water quality standards.
- Define a unified water quality assessment system: Develop a common and inter-calibrated water quality index and related pollution assessment classes that can be implemented in all basin countries, to evaluate the water quality in the river basin in a unified way.
- Improve accuracy in sampling & analysis practices: Review and update the QA/QC procedures applied in all basin countries, towards developing and implementing common procedures in line with the EU WFD.
- Reduce water pollution: Provide technical and financial support to all basin countries in developing an integrated regional river water pollution abatement program that will include environmental compliance action plans for the main sources of pollution in the river basin, including an assessment of the estimated cost to implement these compliance plans.
- Improve data analysis for decision making: Strengthen the countries' capabilities to analyze water quality monitoring data, towards developing decision support systems using mathematical models and GIS techniques.
- Improve data sharing on water quality: Develop mechanisms for water quality data sharing between the riparian countries for the transboundary rivers. One of the mechanisms that could be applied is the establishment of a permanent taskforce group for water quality monitoring information, to define the transboundary stations to be monitored by each country, the number of parameters to be measured, the frequency of measurements, the reporting format for these data and the responsible authority in each country to collect and analysis these data. This information can be used to meet the countries' obligations in international agreements, for example the information needed for the Caspian Sea program. Efforts should be made to encourage other basin countries - Turkey and Iran - to cooperate in providing required information on water quality in their river basins.
- Improve quality control: Support all basin countries in establishing a national reference laboratory for water quality monitoring in each country, responsible to provide technical support to other water quality laboratories in that country, and ensure the proper implementation of the QA/QC procedures. The national reference laboratories will run regular proficiency tests of laboratory analyses applied for the main pollutants, and will evaluate the performance of other national laboratories based on these tests.
- Assessment of the quantity and quality of groundwater aquifers: Due to the lack of proper data on the quantity and quality of groundwater aquifers in the river basin, the assessment of water quality in groundwater aquifers was not included in this report. A regional effort should be made to complete an assessment of groundwater availability in the Kura Ara(k)s basin for both quantity and quality. This assessment should serve to developing national plans for the conjunctive use of both surface and groundwater resources, to meet current and future demands for water.
- Introduce best practices: Implement pilot programs in all basin countries to demonstrate the use of the best available technologies in water quality analysis and assessment, as well as pollution prevention from industrial and municipal sources. Experiences with constructed (engineered) wetlands for sewage water treatment in small villages can be implemented in the basin countries as a low-cost technology most suitable for small communities. The budgets will be based on the specifics of the pilot projects designed for demonstration in each country.

In conclusion, the Kura Ara(k)s river basin has historically suffered from high stresses by human activities, especially in the second half of the twentieth century, which has led to a drastic negative impact on the quality and quantity of the water in the river basin. Ranges of factors, including industrial pollution, domestic waste, agricultural pesticides, large-scale irrigation/flood control and hydropower schemes in addition to terrestrial watershed degradation have significantly affected the basin. All riparian countries have contributed to this situation. However, as some countries in the region experienced a significant economic decline during the last decades, the stress on water quality in some parts of the river has decreased, at least temporarily. For the future, as the economies in the region are envisioned to grow, with some industrial activities already being restored, and with an envisioned decrease of the annual flood volume resulting from climate change, it is expected that threats to river water quality will again increase.

Therefore, the riparian countries are invited to consider the above listed recommendations to improve the management of water quality in the region. These recommendations should be further discussed between the basin countries, to agree on a priority list for actions to improve water quality management in transboundary rivers. This list of priorities should be translated into a regional program of measures, with appropriate timetable and required resources for implementation. The countries may seek the support of the donor community in filling technical and financial gaps in available resources in each country for an efficient implementation of the plan of measures.