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Analysis of the Ecological State of the Agstev and Getik Rivers using Background Concentrations

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Abstract. According to the article, the Water Framework Directive, developed by the European Union, has been instrumental in shifting the assessment of river water quality in Armenia from a focus on maximum permissible concentrations of chemical water quality indicators to a more holistic approach that incorporates natural background concentrations. This transition, which has been in effect since 2011, underscores in the approach to water quality management, emphasizing the importance of ecological integrity and the utilization of natural reference points for evaluating water quality. It has been posited that the inherent limitation of maximum permissible concentrations is their inability to account for the distinct characteristics of specific geographical areas. This limitation persists despite the implementation of uniform criteria for assessing rivers within disparate physical and geographical zones. The Resolution of the Government of the Republic of Armenia "On the Establishment of Water Quality Standards for Each Basin Management Authority" delineates five distinct classes. Each class is designated by a color: "excellent" (1st class — blue), "good" (2nd class — green), "average" (3rd class — yellow), "unsatisfactory" (4th class — brown), and "poor" (5th class — red). The overall evaluation of water chemical quality is predicated on the class with the least favorable quality indicator. The water quality classes of the Agstev and Getik rivers for the period 2013-2024 are examined through the analysis of background concentrations. The investigation revealed that, subsequent to 2021, the water quality of the Agstev and Getik rivers exhibited a decline at all monitoring points located beyond the urban centers of Dilijan, Ijevan, and Chambarak. This decline was attributed to the impact of untreated or inadequately treated domestic wastewater from these cities.

1. INTRODUCTION

A thorough evaluation of surface water contamination involves a series of successive steps aimed at acquiring precise data regarding the extent of water contamination or its quality. This is achieved by employing indicators that characterize the composition and properties of water, taking into account the intended uses of water and its consumption within the designated water body. The assessment of the ecological status of rivers entails the utilization of comprehensive indicators for the concurrent quantitative evaluation of water pollution, predicated on a diverse array of quality indicators (Kashintsev et al., 1990; Nikanorov, 2005). The majority of the comprehensive characteristics of the state of water bodies developed to date are, in one way or another, related to the existing maximum permissible concentrations (MPC) (Kashintsev et al., 1990; Nikanorov, 2005). Surface water pollution standard: MPC, developed in the 70s of the last century in the former USSR, was used to assess the pollution of water systems used for fishery purposes. However, MPC has the following shortcomings:

a) the terrain features are not taken into account; the same standards are applied to rivers flowing in different physical and geographical zones.
b) the natural background content of pollutants in water systems is not taken into account.
c) more than 1000 hydrochemical indicators have been determined.
d) for a number of indicators (copper, vanadium, chromium, etc.), illogically very low MACs have been set, while for nitrate ion, on the contrary, high values have been set.

In accordance with the Water Framework Directive (WFD) (2000/60/EC), developed by the European Union (EU), all European surface waters must achieve good ecological status by 2015. Water bodies with poor water quality must improve to a better status through targeted quality changes (Directive 2000/60/EC). Each EU member state has developed a classification system for water quality in accordance with the WFD. For instance, the Danube River basin's water quality assessment under the EU WFD program is carried out according to individual indicators (Water Quality in the Danube River Basin, 2005). In this classification scheme, the indicators are divided into five classes. The first class is called the "reference" or background concentration (BC); the second class is the target value to be achieved. Classes three through five are part of the "non-achievable" classification scheme, and their values are typically two to five times higher than the target value.

The chemical classification scheme for water quality, which was developed in Germany, consists of four main classes and three subclasses. The resulting assessments are presented in a color-coded display (Irmer et al., 2013). Due to the lack of biological monitoring in river water quality assessments, the EU Water Framework Directive (WFD) uses only chemical water quality indicators to assess water. Natural background concentrations of hydrochemical indicators were considered. BC is the concentration value of a water quality indicator before exposure to any source of pollution. Thus, the government of Armenia (Resolution No. 75-N, March 27, 2011) established a new system for assessing surface water quality in Armenia for each water quality indicator and watercourse. The new water quality standards in Armenia have two advantages. First, the classification of environmental standards is based on natural BC. Second, the choice of indicators considers the load on the surface waters of the Republic of Armenia (based on 43 water indicators).

Based on hydrochemical monitoring, calculations of BC were carried out for the rivers of the Republic of Armenia from 2005 to 2010. Since 2013, Armenia has used BC instead of MPC to assess and classify the quality of river water in accordance with the EU's Water Framework Directive (WFD, 2000/60/EC) (Pirumyan et al., 2019; Simonyan et al., 2020; Simonyan, 2021). The

water quality of the rivers of Lake Sevan and several reservoirs in Armenia (Simonyan, 2021), as well as the Hrazdan (Simonyan et al., 2020) and Debed (Pirumyan et al., 2019) rivers has been assessed using BC. This study aims to evaluate the water quality of the Agstev and Getik rivers using BC.

2. EXPERIMENTAL

2.1. Study Area

The river Agstev is the right tributary of the Kura. The length is 133 km, the basin area is 2,589 km ². It starts in the territory of Armenia, on the north-western slope of Tezhler mountain - one of the peaks of the Pambak mountain range. In the upper reaches of Agstev there is a mountain river flowing in a narrow wooded gorge, somewhat widening near the city of Dilijan. Below there is a wider valley. The largest tributaries are Bldan, Sarnajur, Voskepar, Getik, Agdan [10]. There are four sections on the Agstev River (monitoring posts): No. 15 - 1.2 km above Dilijan, No. 16 - 0.5 km below Dilijan, No. 17 - 1.0 km above Ijevan, No. 18 - 8.0 km below Ijevan .

The river Getikik is the right tributary of the river Agstev. The length of the river is 48 km. It originates on the eastern slope of the Sevan Ridge near the top of Kashatakh. On the river Getik there are two sections: No. 19 - 0.5 km above the town of Chambarak and No. 20 - the mouth of the river.

2.2. Method of Water Quality Classification

According to the Government of the Republic of Armenia's decision "On the Establishment of Water Quality Standards for Each Water Basin Management District," five classes are distinguished. Each class is designated by color (see Table 1): "excellent" (1st class - blue), "good" (2nd class - green), "average" (3rd class - yellow), " unsatisfactory" (4th class - brown) and "bad" (5th class - red). The overall assessment of the chemical quality of water is formed by the class of the lowest quality indicator. Thus, if different quality indicators of a surface water body fall into different quality classes, the final classification is considered to be the worst. The following principle is applied: "If someone is in bad shape, then everyone is in bad shape" or the principle "someone went out, everyone went out"

Table 1. Water quality classification according to the EU WFD.

Water quality class	Assessment	Water quality
1		Excellent
2		Good
3		Average
4		Unsatisfactory
5		Bad

3. RESULTS AND DISCUSSION

Table 2 shows the water quality classes of the Agstev and Getik rivers for 2013-2024. The water quality data for the Agstev and Getik rivers according to BC are taken from the website of the state non-profit organization “Hydrometeorology and Monitoring Center” of the Ministry of Environment of the Republic of Armenia(On the results of ecological monitoring of the environment of the Republic of Armenia. Bulletin. 2013-2024).

In 2013, the water quality at all observation points was excellent (first class) or good (second class), except downstream of Dilijan, where it was average (third class) due to ammonium ions. By 2014, the sections below Dilijan were assessed as "insufficient" (fourth class). Below Dilijan, the water quality was assessed as "average" (4th class), and near the border, it was assessed as "average" (3rd class) due to the presence of ammonium and phosphate ions. In 2015, the water in the upper reaches of the Aghstev River, above Dilijan, was of "good" quality (second class). In the sections below Dilijan, above Ijevan, and near the border, the water was "average" (third class). The water was assessed as "average" (3rd class) below Dilijan due to ammonium ions and suspended particles; above Ijevan due to COD, ammonium ions, and suspended particles; and near the border due to COD, ammonium and phosphate ions, and suspended particles. In 2016, the water quality was "good" (class 2) at all observation points.

Table 2. Classification of Water quality of the Riverd Agstrv and Getik based on the water quality Armenian standards.

River	Agstev				Getik	
	15	16	17	18	19	20
2013						
2014						
2015						
2016						
2017						
2018						
2019						
2020						
2021						
2022						
2023						
2024						

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Dilijan, where it was average (third class) due to ammonium ions. By 2014, the sections below Dilijan were assessed as "insufficient" (fourth class). Below Dilijan, the water quality was assessed as "average" (4th class), and near the border, it was assessed as "average" (3rd class) due to the presence of ammonium and phosphate ions. In 2015, the water in the upper reaches of the Aghstev River, above Dilijan, was of "good" quality (second class). In the sections below Dilijan, above Ijevan, and near the border, the water was "average" (third class). The water was assessed as "average" (3rd class) below Dilijan due to ammonium ions and suspended particles; above Ijevan due to COD, ammonium ions, and suspended particles; and near the border due to COD, ammonium and phosphate ions, and suspended particles. In 2016, the water quality was "good" (class 2) at all observation points.

In 2017, the water quality of the Aghstev River was "good" (second class) in the sections above and below Dilijan and "average" (third class) in the sections above Ijevan and near the border. The Getik River's water quality is "good" (2nd class) at the river mouth and "unsatisfactory" (4th class) above Chambarak.

In 2018, the water quality of the Aghstev River was assessed as "good" (second class) upstream and downstream of Dilijan, "average" (third class) upstream of Ijevan and near the border due to iron, nitrite ions, and suspended matter. The water quality of the Getik River was assessed as "average" (third class) upstream of Vahan due to iron, aluminum, and suspended matter and as "good" (second class) at the mouth.

In 2019, the water quality of the Aghstev River was assessed as "good" (2nd class) in the sections above and below Dilijan and Ijevan. In the section below Ijevan, it was assessed as "average" (3rd class) due to phosphate ions and suspended substances. The water quality of the Getik River above Vahan was assessed as "average" (third class) due to iron and suspended solids. At the river's mouth, the water quality was assessed as "good" (second class).

In 2020, the water quality of the Aghstev River was evaluated. The sections of the river upstream and downstream of the city of Dilijan were rated as "good" (2nd class), while the sections of the river upstream and downstream of the city of Ijevan were rated as "unsatisfactory" (4th class). These ratings were due to nitrite ion and suspended matter levels. The water quality of the Getik River was assessed as "average" (third class) due to aluminum and iron in the section upstream of the village of Vahan and as "good" (second class) in the estuary section.

In 2021, the observation points of the Aghstev River above and below Ijevan changed from class 2 to class 3. The observation points of the Getik River above Vahan village and at the mouth changed from class 3 to class 4 and from class 2 to class 5, respectively.

The water quality of the Aghstev River was evaluated as "average" (third class) in 2022, with the classification applying to the river's segments upstream and downstream of Dilijan city, as well as those upstream and downstream of Ijevan city. The assessment was due to the presence of iron and suspended solids upstream of Dilijan city; nitrite ions downstream of Dilijan city; ammonium ions, manganese, iron, barium, and suspended solids upstream of Ijevan city; and ammonium and nitrite ions, iron, barium, total phosphorus, and suspended solids downstream of Ijevan city. The water quality of the Getik River was assessed as "average" (3rd class) upstream and downstream of Vahan village. Ammonium ions, iron, and suspended solids are present upstream of Vahan village. Barium and ammonium ions are present at the river's mouth.

The water quality of the Aghstev River was assessed as "average" (3rd class) in 2023. This assessment was based on samples collected from the river sections above and below the cities of Dilijan and Ijevan. The assessment was due to the presence of iron and suspended solids above Dilijan, nitrite ions below Dilijan, ammonium ions, manganese, iron, barium, and suspended solids above Ijevan, and ammonium and nitrite ions, iron, barium, phosphate ions, and suspended solids below Ijevan. The water quality of the Getik River was assessed as "average" (3rd class) in the sections above and at the mouth of the river. Ammonium ions, iron, and suspended solids are present above the village of Vahan. Ammonium ions and barium are present at the river's mouth.

So, in 2024, they did this assessment of the water quality of the Aghstev River, and they found that the water quality in the sections above Dilijan City and above and below Ijevan City was "unsatisfactory," which is like the fourth class. The section above Dilijan was assessed as "average" (3rd class) due to ammonium, nitrite ions, iron, and suspended solids, while the sections above and below Ijevan were assessed as "unsatisfactory" (4th class) due to iron and beryllium. The water quality of the Getik River was assessed as "unsatisfactory" (4th class) in the sections above Vahan village and at the mouth. The presence of iron, beryllium, and aluminum in the mouth section is attributable to the section above Vahan village.

Finally, Table 2 shows that deterioration of the water quality of the Aghstev and Getik rivers has been observed at all observation points after 2020.

Table 3. Environmental standards for the quality of river water in the Agstev River basin.

Quality parameters	**MPC**	**Water quality class according to BC**					**Units**
		I	**II**	**III**	**IV**	**V**	
COD_{Cr}	30	10	25	40	80	>80	$mg/_{O2}L$
NH_4^+	0.5	0.122	0.4	1.2	2.4	>2.4	mg/L
NO_2^-	0.08	0.016	0.06	0.12	0.3	>0.3	mg/L
PO_4^{-3}	0.1	0.048	0.1	0.2	0.4	>0.4	mg/L
Suspended solids	10	12.8	15.3	25.5	51.0	>51.0	mg/L
Fe	0.1	0.058	0.116	0.5	1	>1	mg/L
Al	40	252.7	508.4	1010.8	5000	>5000	μg/L
Mn	10	26.0	52.0	104.0	208.0	>208.0	μg/L.
Ba	700	12.5	25	50	1000	>1000	μg/L.
Be	0.6	0.026	0.051	0.102	100	>100	μg/L.

As previously mentioned, the MPC's limitations stem from its failure to account for the distinct characteristics of the terrain. This results in the application of uniform standards to rivers that traverse diverse physical and geographical regions. As illustrated in Table 3, the BC (class I water quality) of the Agstev River basin deviates from the MPC.

4. CONCLUSION

Thus, it has been shown that since 2011, when assessing the quality of river water in Armenia, instead of maximum permissible concentrations of chemical indicators of water quality, natural background concentrations are used in accordance with the Water Framework Directive developed by the European Union.

In 2013, the water quality of the Aghstev River at point 15 was assessed as "excellent" (class 1). From 2014 to 2021, the water quality was "good" (class 2). From 2022 to 2023, the water quality was assessed as "average" (class 3), and in 2024, the water quality was "unsatisfactory" (class 4).

At point 16, the water quality was assessed as "average" (class 3) in 2013, 2015, and from 2022 to 2024 due to the presence of ammonium ions and suspended matter. In 2014, the water quality was "unsatisfactory" (class 4) due to ammonium and phosphate ions. From 2016 to 2019, the water quality was "good" (class 2).

The water quality of the Aghstev River at point No. 17 in 2013-2014, 2016 and 2019 was "good" (2nd class), and in 2015, 2017-2018 and 2021-2023 - "average" (3rd class), in 2020 and 2024 the water was of "unsatisfactory" quality (4th class).

In 2013 and 2016, the water quality of the river at point No. 18 was "good" (2nd class), and in 2014-2019 and 2021-2023 it was assessed as "average" (3rd class) due to phosphate, ammonium and nitrite ions, due to iron and suspended solids. In 2020 and 2024, the water was of “unsatisfactory” quality (4th class).

The water quality of the Getik River at point 19 was assessed as “excellent” (1st class) in 2013. In 2014-2016, the water was of “good” quality (2nd class). In 2018-2020, 2022,2023, the water quality was assessed as “average” (3rd class), and in 2017, 2021 and 2024, the water was of “unsatisfactory” quality (4th class).

In point 20, the water quality was assessed as “excellent” (1st class) in 2013. In 2014-2020, the water was of “good” quality (2nd class). In 2022,2023, the water quality was assessed as “average” (Class 3). In 2024, the water was of “unsatisfactory” quality (Class 4), and in 2021, the water was of “bad” quality (Class 5).

It was shown that after 2021, the water quality of the Aghstev and Getik rivers at all observation points deteriorated. Therefore, the water quality of the Aghstev River deteriorates outside the cities of Dilijan and Ijevan, and for the Getik River after the city of Chambarak, which can be explained by the impact of untreated or insufficiently treated domestic wastewater from the mentioned cities and unorganized runoff from the fields.

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