Environment and Ecology Research 13(2): 251-256, 2025 http://www.hrpub.org
DOI: 10.13189/eer.2025.130206

Assessment of the Microbiological Indicators of the River Water Used for Irrigation in the Field of Korca

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Received November 22, 2024; Revised March 27, 2025; Accepted April 14, 2025

Cite This Paper in the Following Citation Styles

(a): *[1] Sulltanë Ajçe, Adrian Maho , "Assessment of the Microbiological Indicators of the River Water Used for Irrigation in the Field of Korca," Environment and Ecology Research, Vol. 13, No. 2, pp. 251 - 256, 2025. DOI: 10.13189/eer.2025.130206.*

(b): *Sulltanë Ajçe, Adrian Maho (2025). Assessment of the Microbiological Indicators of the River Water Used for Irrigation in the Field of Korca. Environment and Ecology Research, 13(2), 251 - 256. DOI: 10.13189/eer.2025.130206.*

Abstract Today, pollution of ecosystems from various sources constitutes one of the most significant concerns in our society. The objective of this study is to evaluate the microbiological quality of the Devoll and Dunavec rivers using key indicators to determine their suitability for agricultural irrigation and food safety. The river water quality for agricultural purposes is evaluated through physical, chemical, and biological indicators. It is estimated that the primary contamination of agricultural products, especially vegetables, by pathogens originates from water. Microbiological indicators are quite important for assessing water quality for agricultural purposes as well as for identifying various pollutants. The present study utilized standard analytical methods to evaluate the most important microbiological and chemical indicators in the waters of the Devoll and Dunavec rivers. Based on the analyzed data of microbiological and chemical indicators such as *Escherichia coli*, Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), and Total Suspended Solids (TSS), the waters of the Devoll and Dunavec rivers are classified as Class 2. These waters are not suitable for food crops to be consumed fresh, where the edible parts are in direct contact with the water, or for root crops that are consumed raw. Overall, the waters of these rivers are considered suitable for irrigating other crops. The study's reliance on microbiological indicators of the waters of the Devoll and Dunavec rivers identified potential sources of pollution, contributing so in determining pathways for improving ecosystems and food safety.

Keywords Water Quality, Microbial Pathogens, Microbial Risk Assessment, Pollution, *Escherichia coli*

1. Introduction

Pollution of ecosystems is one of the major global concerns today. River ecosystem pollution has serious consequences in multiple aspects. The quality of river water significantly affects aquatic life, agricultural irrigation, soil health in irrigated areas, and the quality of food products. The study evaluated the microbiological indicators of the Devoll and Dunavec rivers for agricultural use and identified potential sources of pollution. The Korça field is traversed by two main rivers: the Devoll River and the Dunavec River. The Devoll River (196 km) is one of the primary rivers in Albania. Its waters are used to irrigate approximately 10,000 hectares of land in the Korça region. The Dunavec River is the main river in the southern part of the Korça field. It flows through the field from south to north for about 15 km before joining the Devoll River near Maliq. The waters of the Dunavec River are utilized for irrigating the lands of the farmers in the municipalities of Korca and Maliq through a dam built near the village of Turan and water-lifting gates near the national bridge in Bulgarec.

The quality of these rivers' waters is significantly affected by human activities, including the discharge of wastewater, the use of various chemicals for domestic purposes, the dumping of waste into the rivers, pesticide treatment of agricultural plants, particularly orchards, and fertilization of crops [1].

Agriculture is a sector significantly impacted by pollution. Thus, agricultural production can only be optimally achieved in the presence of a suitable ecological environment. Microbiological indicators are used to describe the characteristics of a specific biosphere and assess pollution in terrestrial and aquatic ecosystems. The most important microbiological indicators regarding water quality for irrigation of crops include *Escherichia coli*, Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), and chloride content (Cl^-). Flowing water absorbs oxygen from the atmosphere. Various chemical reactions and the decomposition of organic materials consume oxygen. Wastewater contains organic materials decomposed by microorganisms, which use oxygen in the process [1]. Cl^- in river waters plays an important role in reducing the content of *Escherichia coli* [2], [3]

Hence, indicators such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS), and chloride content serve as indirect markers for evaluating river water quality from a microbiological perspective. The anthropogenic factor is considered the main contributor to the deterioration of water quality in Albania [4], [5]. Surface water pollution in Albania has increased in recent years [6], [7]. Numerous studies have been conducted to assess the microbial quality of drinking water and the impact of agricultural activities on ecosystem pollution. Recently, several researchers have focused their research efforts on evaluating the microbial quality of irrigation water used for agricultural production, particularly for vegetables [8], [9], [10]

Water can be a direct source of contamination in the production of fresh crops. Many researchers identify irrigation water as a source of pathogenic microorganisms in agricultural production [11], [12], [13]. Pathogenic microorganisms associated with irrigation water include bacteria, viruses, and parasites (protozoa and helminths). Although viruses and parasites are of great importance and can be transmitted to fresh products (fresh lettuce, fresh onions, leek, turnip, cabbage, fresh oregano, etc…) through irrigation water, this paper focuses mainly on pathogenic bacteria. Microbiological indicators of river water used for irrigating crops are not only useful for the aforementioned purposes but also for studying ecosystem changes caused by pollution. They can be used to detect alterations in ecosystems due to pollution.

The primary document used as a basis for assessing the microbiological quality of the waters of the Devoll and Dunavec rivers for agricultural purposes is EU Regulation 2020/741 of the European Parliament and Council on minimum requirements for water reuse. It aims to establish standards for water quality for agricultural purposes. This regulation specifies quality requirements for several parameters, including *Escherichia coli*, Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), and Total Suspended Solids (TSS). Pathogenic microorganisms in water used for irrigating crops pose the most significant risk for contamination of fresh produce and human and animal health [14], [15], [16].

To evaluate water suitability, it is essential to compare microbiological indicators with minimum requirements based on the "fit for purpose" approach [17]. The main health risk is the consumption of vegetables irrigated with contaminated water, especially by microorganisms [18]. Crop growers can evaluate water sources through a monitoring regime. The integration of microbiological, chemical, and physical pollutant indicators is extremely meaningful, as it holistically assesses the issue under study.

The purpose of this study is to apply scientific methods related to the assessment of the microbiological quality of the waters of Korça's field rivers, evaluate the causes, and manage the pollution risk. Additionally, the aim is to ensure the production of agricultural products that are safe for consumers.

2. Materials and Methods

The water sampling points for conducting the analyses were taken at the entrance of the irrigation schemes rrefered in figure 1. The first sampling point is the Zemblak dam, at the entrance of the Devoll River water into the irrigation scheme of the Kor çë field, with coordinates N 40°42'9.1152'' E 20°53'14.6004''.

The second sampling point is the dam near the bridge of Voskop village, at the entrance of the Dunavec River water into the irrigation scheme of the Bulgarec field, with coordinates N 40°37'20.55'' E 20°44'14.3052''. The sampling site (in the Zemblak village dam) for analysis was chosen in those parts of the aquatic environment where water mixing is optimal. Samples were analyzed in the Agro-Food Laboratory and the Microbiology Laboratory of the Faculty of Agriculture, at 'Fan S. Noli' University of Korce.

Sampling and Analysis Schedule: July-September, monthly, year 2024.

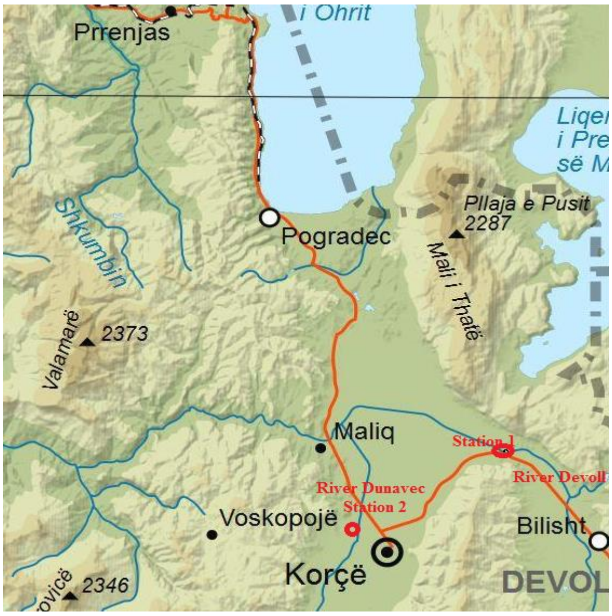

Figure 1. View of the monitoring sites along the Devoll and Dunavec river

The collection and preservation of water samples were carried out according to ISO 5667-3:2024. This document specifies requirements for sampling, transportation, and preservation of water samples for physicochemical, chemical, hydrobiological, and microbiological analyses.

The analyzed indicators of the Devoll and Dunavec river waters are presented in Table 1.

Types and models equipment used: water quality sampling kits, Spectrophotometer Iris, pH meter, microscope and microbial culturing tools. Standard analysis methods (ISO 7899-2:2000) were used to assess the microbiological quality of the waters of the Devoll and Dunavec rivers, comparing them with the standard water values for irrigation according to EU Regulation 2020/741. This regulation defines various water quality parameters for different categories of crops, which depend on the potential contact between water and the crop, the final use of the crop (e.g., raw consumption, food processing, industrial uses), and the irrigation method, as shown in Table 2.

The integrated use of microbiological indicators of river water quality determines the quality class. This is a quite meaningful indicator. This classification, according to EU Regulation 2020/741, is presented in Table 3.

Table 1. Analyzed Indicators of the Waters of the Devoll

Indicators	**Description**
Escherichia coli cfu/100 ml)	Fecal contamination microorganism. Sanitary index.
Biochemical oxygen demand NBO_5 (Oxygen Demand (BOD_5)	The concentration of dissolved oxygen consumed under specific conditions with biochemical oxidation of organic and/or inorganic substances in water over 5 days.
Chemical oxygen demand (COD)	The concentration of oxygen consumed through chemical oxidation.
Total Suspended Solids (TSS) (mg/l)	The solid substances remain on the filter after filtration under specified conditions.
Cl^- (Chloride)	The concentration of Cl^-

Table 2. Method for measurement and Standard values for irrigation water

Number	**Indicators**	**Method for measurement**	**Units**	Standard values for irrigation water
1.	Escherichia coli (cfu/100 ml)	ISO 7899-2:2000	cfu/100 ml	0-1000
2.	Biochemical oxygen demand NBO_5 (Oxygen Demand (BOD_5)	ISO 5813-1983	mg/l	0-18
3.	Chemical oxygen demand (COD)	ISO 6060-1989	mg/l	4-7
4.	Total Suspended Solids (TSS) (mg/l)	ISO 11923:1997	mg/l	25-50
5.	Cl^-	ISO 9297:2000	mg/l	0-30

Table 3. Limit values of chemical parameters in rivers according to the EU Water Framework Directive (WFD) (2000/60/EC) dated 23 October 2000

Indicators	**Units**	Limit values of microbiological parameters				
		High status, Class I	Good status, Class. II	Moderate status Class. III	Poor status Class. IV	Bad status Class. V
Escherichia coli	cfu/100 ml	≤ 10	≤ 100	≤ 200	≤ 500	≤ 1000
COD	mg/l	**>7**	**>6**	**>5**	**>4**	**<3**
BOD_5	mg/l	**<2**	**<3.5**	**<7**	**<18**	**>18**

3. Results

The section of the Devoll River where we conducted analyses covers approximately 7,200 hectares. The main crops cultivated in this area include cereals, legumes, potatoes, sugar beet, vegetables, medicinal plants, fruit trees, and others. These crops exhibit different responses to the microbiological indicators of the irrigation water content.

Microbiological and chemical analyses of the Devoll River water, conducted throughout the entire irrigation season based on standard methods, are presented in Table 4.

The assessment of the microbiological quality of river waters is determined based on a comparison with the allowable standards set in the EU Water Framework Directive (WFD).

Based on the analysis data, it is concluded that the waters of the Devoll River are within the allowable standards regarding the indicators of Escherichia coli content and Biochemical Oxygen Demand (BOD_5). The Chemical Oxygen Demand (COD) exceeds the permissible standards in July. The content of Cl^- is above the permissible standards. The high presence of Cl^- is linked to water pollution from human activity. The use of detergents and Cl^- for disinfecting drinking water through wastewater is discharged into the Devoll River. According to the content of Escherichia coli, the main microbiological indicator, the waters of the Devoll River are classified as Class 2. These waters are not suitable for food crops that are consumed fresh, where the edible part comes into direct contact with water, or for root crops consumed raw. In an integrated manner, the waters of this river are considered good for irrigating other crops.

The microbiological and chemical analyses of the water from the Dunavec River, carried out throughout the irrigation season, based on standard methods, are presented in Table 5.

The waters of the Devoll and Dunavec rivers are classified as Class 2, meaning they are not suitable for irrigating food crops consumed fresh or root crops that are eaten raw but can be used for other agricultural purposes.

Table 4. Microbiological and chemical analyses of the water of the Devoll River

No	**Indicators**	**Units**	Standard values for irrigation water	The time when the analysis was performed		
				14/07/2024	12/08/2024	09/09/2024
1.	*Escherichia coli*	cfu/100 ml	0-1000	28	22	20
2.	Total Dissolved Solids	mg/l	0 – 2000	160	80.6	24.8
3.	Solid matter	mg/l	0 – 2000	325	330	354
4.	COD	mg/l	4-7	13	7	2
5.	BOD_5	mg/l	0-18	7,37	2,8194	4,829
6.	Cl^-	mg/l	0-30	56,8	56,8	31,95

Table 5. Microbiological and chemical analyses of the water of the Dunavec River

Nr	**Indicators**	**Units**	Standard values for irrigation water	The time when the analysis was performed		
				14/07/2024	12/08/2024	09/09/2024
1.	*Escherichia coli*	cfu/100 ml	0-10000	44	38	36
2.	Total Dissolved Solids	mg/l	0 – 2000	60	40.4	19.8
3.	Solid matter	mg/l	0 – 2000	328	330	325
4.	COD	mg/l	4-7	23	11.5	3
5.	BOD_5	mg/l	0-18	3,72	2,4	1.9
6.	Cl^-	mg/l	0-30	35,5	21,3	30,4

4. Discussion

The results produced through this study are significant as the microbiological indicators of the waters in both the Devoll and Dunavec Rivers show serious problems regarding their use for agricultural purposes. The deterioration in their quality indicators is a result of ecosystem pollution. Improving the quality of river waters requires intervention in wastewater treatment, reforestation, the introduction of biological methods for plant cultivation, and ecological awareness within communities.

Based on the analyzed data from the river ecosystem, the presence of pathogenic microorganisms in water used for irrigation mainly comes from fecal contamination, a conclusion supported by a range of research [19], [20]. *Escherichia coli* is part of the coliform bacteria group and is considered an indicator of contamination from sewage. Many researchers have used *E. coli* and coliform populations as indicators for assessing microbiological safety [21], [22],[23]. The study confirmed significant relationships between indicators such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS), and the microbiological content of river waters. This is also confirmed by the above-mentioned researchers.

5. Conclusions

Microbial pollution of freshwater ecosystems in rivers, as a result of human activity, is one of the most significant concerns regarding the sanitary quality of water used for agricultural purposes. The presence of pathogenic bacteria in river water represents the primary route for the contamination of agricultural products. Protozoa and viruses are serious threats to human health. Based on the analyzed data of microbiological indicators, the waters of the Devoll and Dunavec Rivers are classified as Class 2. These waters are unsuitable for crops that are consumed fresh, where the edible parts are in direct contact with water, and for root crops that are consumed raw. The installation of wastewater treatment plants is essential for improving the quality of the ecosystem and ensuring safe food products. Both rivers are polluted by human activity, specifically wastewater and organic matter, contributing to microbial contamination. The study confirms the presence of *Escherichia coli* as an indicator of fecal contamination, which makes the waters unsuitable for certain crops, such as fresh food crops or root vegetables. The study recommends improving water quality through wastewater treatment plants, reforestation, and the adoption of biological farming practices. Recommendations: Wastewater treatment**:** Install or upgrade treatment plants to reduce the microbial and chemical contamination in the rivers. Ecosystem restoration**:** Implement reforestation projects to help improve water quality naturally. Community awareness**:** Increase public awareness about the environmental impacts of wastewater and other pollutants. Alternative irrigation practices**:** Consider using alternative water sources for crops that are consumed raw or have direct water contact.

This research underscores the need for stricter pollution control measures to safeguard the health of both ecosystems and consumers.

Conflict of Interest

There is no conflict of interest to declare.

Acknowledgements

The authors thank: "Fan S. Noli" University and the Faculty of Agriculture for all the opportunities they created for us to carry out the study.

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