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Evaluation of the water quality of the rivers used for the irrigation of the Korçë field, Albania

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Abstract. Water from multiple sources, including rivers, streams, springs, lakes, irrigation reservoirs and groundwater is used to irrigate agricultural crops. Crop productivity depends not only on sufficient amount of water, but also on its good quality. The quality of irrigation water affects not only plant productivity but also product quality and food safety. The study conducted a dynamic assessment of the water quality of two main rivers, the Devoll River and the Dunavec River, which are used for the irrigation of the Korçë field, Albania. The study evidenced the impact that human activity has on water pollution of these various chemicals during the use of water for family purposes, the disposal of waste into rivers, the treatment of agricultural plants with pesticides, and the cutting down of forests. The analyses of physico-chemical and biological indicators were performed according to standard methods in the Agro-food laboratory of the Faculty of Agriculture, Fan Noli University, Korçë. The indicators resulting from the analysis were compared with the standards set by FAO for irrigation water quality and EU Regulation 2020/741. The pollution of the ecosystem of these rivers has led deterioration in their quality indicators. Interventions in wastewater treatment, reforestation, the introduction of biological methods for combating diseases and pests, and the ecological awareness of communities are contributions towards improving the quality of river waters.

Key words: Water quality, Devolli River, Dunavec River, irrigation of crops, physico-chemical indicators of water.

Introduction

Water is one of the main factors for the life of people, animals, plants and for the economy. A large amount of water is used in the agricultural sector. It should be used sustainably, both quantitatively and qualitatively.

Concerns about the quality of water were less until recently because the possibility of supplying good quality water was greater. This situation is now changing as a result of the increase in maintenance costs of the irrigation infrastructure from these sources, as well as the increase in water pollution from human activities (Inyinbor et al., 2018; Sagasta et al.,2017; Tekile, 2023).

The Korça plain is the largest lowland in the southeastern part of Albania, with an area of about 300 km^2. For the first time, the aim is to assess the water quality of the rivers of Korça for use for agricultural purposes.

The Korça plain is crossed by two main rivers - the Devoll River and the Dunavec River. The Devoll River (196 km) originates from the foot of Mount Gramoz, continues its course north towards the city of Bilisht, then turns west through the gorge between Mount Dry in the north and Morava in the south, passing through the plain of Korça. The stream of Devoll joins many branches that describe almost 44 villages of the Municipality of Devoll. A dam has been built at the mouth of Cangonji, which uses the waters of this river to irrigate the fields of a large number of villages in the administrative unit of Pojan, Vreshtas, and Maliq. The smallest monthly flows of the Devoll river are about 1.9 m^3/sec in August, the largest

ones about 16.4 m^3/s in March; the average annual flow is 6.72 m^3/s (Pano, 1984).

Dunavec is the main river of the southern part of the Korça plain. This river crosses the Korça plain from south to north for about 15 km until the vicinity of Maliqi, where it flows into the Devolli River. The waters of Dunavec River, through a dam built on the bridge near the village of Turan and the water lifting gates near the national bridge in Bulgarec, are used to irrigate the agricultural lands of farmers in the municipalities of Korçë and Maliq.

These rivers are important sources for the irrigation of plants. Irrigation in agriculture depends not only on the sufficient water quantity, but also on its good quality. Water quality is determined by the purpose for which it will be used. Among its most common uses is for irrigation. Water of good quality has the potential capacity to allow maximum crop yield. Water of poor quality can cause problems in soil and plants, affecting the yield from their use in specific conditions for the culture and the place of cultivation. The quality of irrigation water affects not only the productivity of plants but also the quality of products and food safety (Linderhof et al, 2021; Saludo et al., 2023). Vegetables have specific requirements regarding the quality of irrigation water.

The quality of water in rivers depends on various factors, such as geology, degree of mineral weathering, ion exchange, groundwater flow and various human activities. It is a well-known fact that human activity through the discharge of wastewater, the use of various chemicals when using waters for family purposes, the disposal of waste into rivers, the treatment of agricultural plants, especially orchards, with pesticides leads to the pollution of river waters. The anthropogenic factor is assessed as the main factor in the deterioration of water quality in Albania (Hoxha et al., 2009; Sulçe et al., 2018). The pollution of Albania's surface waters has increased (Bardhi et al., 2014; Lushaj et al., 2011)

Salts that are soluble in water and easily transported by water contribute to the salinity problem. Some of the salts accumulated from previous irrigations can be displaced. The most common criteria on which the assessment of irrigation water quality is based, include: salinity, content of Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_2^-, NO_3^-, PO_4^{3-} and toxicity of chemical elements. Very important criteria in assessing the quality of irrigation water are temperature, hardness, pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand, (BOD), and pathogenic organisms.

Water, as a basic ingredient for plant life, is highly exposed to pollution (Beqaj et al., 2015). In practice, water is said to be polluted when its chemical, physical and biological qualities deviate from the conditions called normal for a particular use. Determining water quality through inspection alone is insufficient to assess the degree of pollution. It is necessary to indicate the determination of chemical, physical and microbiological parameters.

In chemical parameters, the most common characteristics are: pH or water reaction, salinity. Cations, including sodium, calcium and magnesium, affect the quality of waters for use in irrigation and other purposes (Kundu & Ara, 2019).

The decrease of the osmotic potential of the soil solution as a result of the increase in the salt concentration limits the uptake of water by agricultural plants and reduces their productivity (Mandal et al., 2019).

The increase in salts in irrigation water comes mainly from the increase of Na^+ and Cl^-. The concentration Na^+ and Cl^- will create a large electrochemical gradient that will favor passive transport in the cytosol (Apse & Blumwald, 2007). Na^+ is toxic to cells and an antagonist and competitor of NH_4^+, K^+, Mg^{2+} and Ca^{2+}. Cl^- is antagonistic of nitrate (NO_3^-). As a result, plants will have difficulties obtaining two of the vital elements - nitrogen and potassium (Ketehouli et al., 2019; Pardo & Quintero, 2002; Ran et al., 2022). The high content of salts in irrigation water brings damage not only to the productivity of plants but also to the breakdown of the soil structure (Supriyanto et al., 2022; Wang et al., 2023).

FAO standards for irrigation water quality harmonize social, economic and environmental factors (Ayres & Westcot, 1985; FAO, 1994; Yousif & Chabuk, 2023). Microbiological characteristics are determined by the eventual presence of pathogenic bacteria for humans and animals.

Assessing the quality of river water, comparing chemical, physical and biological indicators with the norms, presents difficulties, since in our country there are still no norms for the quality of water for irrigation of crops. For this reason, we

used the standards set by FAO (FAO, 1994) for irrigation water quality, the EU Water Framework Directive (WFD) and EU Regulation 2020/741.

The aim of the study is to determine the quality of water used for irrigation in the Korça field as well as to assess the quality of river waters used for irrigation, in terms of the impact of urban liquid discharges, agricultural activity and erosion. We also aimed to protect consumer health by identifying the crops that can be irrigated with these waters, as the most suitable irrigation methods based on EU Regulation 2020/741 of the European Parliament and of the Council on minimum requirements for water reuse.

Materials and methods

Water samples for analysis were taken at the entrance of the irrigation schemes. The first sampling point is the Zemblak dam at the entrance of the Devoll river in the irrigation scheme of Korça field with coordinates N 400 42'9.1152" E 200 53'14.6004". The second sampling point is the dam near the bridge in the Voskop village at the entrance of the Dunavec river in the Bulgarec in the field irrigation scheme, with coordinates N 400 37'2055" E 200 44'14.3052". The sampling site was chosen in those parts of the aquatic environment where the mixing of waters is better.

The samples were analyzed in the Agri-Food Laboratory of the Faculty of Agriculture, Fan S. Noli Korce University.

The collection and storage of water samples were done according to ISO 5667-3:2024. This document specifies the requirements for sampling, transportation, and storage of water samples for physico-chemical, chemical, hydrobiological and microbiological analyses.

For the assessment of waters of the Devoll and Dunavec rivers for irrigation of agricultural crops, the specific reactions they have to the components of the water were taken into account. In general, Table 1 was constructed based on the references defined by Ayers & Westcot (1985) and the improvements made by Koegelenberg (2004).

Standard analytical methods were used to assess the quality of the Devoll and Dunavec rivers, comparing them with standard values for irrigation water. These data are presented in Table 2.

The integrated use of river water quality indicators determines the quality class. This is a very significant indicator. The method of this classification is presented in Table 3.

Table 1. The analyzed water indicators of the Devoll and Dunavec rivers.

Indicators	Description
pH	Measuring the activity of hydrogen ions in solution. The pH value is the base 10 logarithm of the molar activity of hydrogen ions multiplied by -1
Electrical conductivity (EC)	The total soluble salts (TSS) content of irrigation water, in micro Siemens per centimeter ($\mu S\ cm^{-1}$)
General alkalinity	The general alkalinity of natural waters is formed by weak acid ions: HCO_3, CO_3^{2-}, HS^-, $HSiO_3^-$, SiO_3^{2-} and other anions that are hydrolysed, forming the OH^- ion. The total alkalinity of the water is expressed in mg. equiv. of the spent acid for its neutralisation to pH = 4, which is achieved by titrating in the presence of methyl orange.
Biochemical need for oxygen, NBO_5	Mass concentration of dissolved oxygen, consumed under conditions specific with biochemical oxidation of organic matter and/or inorganic matter in water for 5 days.
Chemical oxygen demand, COD	Mass concentration of oxygen consumed by chemical oxidation
Nitrite, NO_2	Concentration of nitrogen in nitrite form
Nitrates, NO_3	Concentration of nitrogen in nitrate form
Ammonia, NH_4	Concentration of nitrogen in ammonium form
Orthophosphates PO_4^{3-}	Concentration of phosphorus in orthophosphate form
Total phosphorus, total-P	Total phosphorus concentration. Organic phosphorus and hydrolysed polyphosphates are oxidised with potassium peroxodisulfate to orthophosphates.
Pending case	Solids that remain in the filter after filtration under defined conditions
Alkalinity	The quantitative capacity of the water environment to react with hydrogen ions, expressed in mg/l $CaCO_3$

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

Nr	Indicators	Method for measurement	Units	Standard values for irrigation water
1	Temperature	ISO 7888:1985	°C	>16
2	Electrical conductivity (EC)	ISO 10523: 2012	µS cm^{-1}	0-2250
3	Total Dissolved Solids	ISO 11923:1997	mg/l	0 – 2000
4	Dry residue	ISO 11465:1993	mg/l	0 – 2000
5	Total Alkalinity	ISO 9963:1:1994	mg/l	0-250
6	COD	ISO 6060-1989	mg/l	4-7
7	Ca^{2+}	SSH ISO 6058:2000	mg/l	0-20
8	Mg^{2+}	SSH ISO 6059:1997	mg/l	0-5
9	NBO_5	ISO 5813-1983	mg/l	0-18
10	Cl^-	SSH ISO 9297:2000	mg/l	0-30
11	Nitrite (NO_2-N)	SSH ISO 10048:2000	mg/l	0-0.3
12	NO_3	SSH ISO 10048:2000	mg/l	0-5
13	PO_4^{3-}	SSH ISO 9280:2000	mg/l	0-0.5
14	Total Phosphorus	SSH ISO 9280:2000	mg/l	0-1
15	Acidity	ISO 10523-2008	- log (H^+)	6.0-8.5

Table 3. Limit values of chemical parameters in rivers according to the DKU Water Framework Directive

Indicators	Units	Limit values of chemical parameters				
		High Condition Cl.I	Good Condition Cl.II	Moderate Condition Cl. III	Poor Condition Cl.IV	Bad Condition Cl.V
COD	mg/l	>7	>6	>5	>4	<3
NBO_5	mg/l	<2	<3.5	<7	<18	>18
NH_4	mg/l	<0.05	<0.3	<0.6	<1.5	>1.5
NO_2	mg/l	<0.01	<0.06	<0.12	<0.3	>0.3
NO_3	mg/l	<0.8	<2	<4	<10	>10
PO_4^{3-}	mg/l	<0.05	<0.10	<0.2	<0.5	>0.5
P-total	mg/l	<0.1	<0.20	<0.4	<1	>1

Results

The section of the Devoll river, where we did the analysis, covers about 7200 ha. The main crops cultivated in this area are cereals, legumes, potatoes, sugar beets, vegetables, medicinal plants, fruit trees, etc. These cultures showed different reactions to indicators of the content of irrigation water.

The physico-chemical analyses of the Devoll river water, carried out throughout the irrigation season, based on standard methods, are presented in Table 4. The assessment of river quality is based on physico-chemical parameters by comparing the values obtained with the permitted rates defined in the EU Water Framework Directive (WFD).

Based on the data from the analysis, it was established that the waters of the Devoll River are within the permitted norms in terms of the indicators of Biochemical Need for Oxygen (NBO_5), Nitrites (NO_2-N), Nitrates NO_3^-, Phosphates PO_4^{3-}, Total Phosphorus, and acidity. The chemical oxygen demand (COD) is above the allowed rates in the month of July. Total alkalinity is greater than the allowed rates, and there is a big increase in the month of September. The content of Cl^-, Ca^{2+}, and Mg^{2+} is above the allowed rates. The high presence of these ions is related to the pollution of the waters of this river by human activity. The use of Cl- detergents for disinfection of drinking water is discharged into the Devoll river through the water. The discharge of polluted waters from 44 villages and the city of Bilisht into the Devoll River comes from the lack of wastewater treatment plants. By the way, the waters of this river are considered good for irrigating crops.

Table 4. Values of water indicators of the Devoll 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	25/06/2025
1	Temperature	°C	>16	17	17	14	20
2	Electrical conductivity (EC)	µS cm^{-1}	0-2250	453	362	287	486
3	Total Dissolved Solids	mg/l	0 – 2000	160	80.6	24.8	147
4	Dry residue	mg/l	0 – 2000	325	330	354	332
5	Total Alkalinity	mg/l	0-250	294	317	646	302
6	COD	mg/l	4-7	13	7	2	11
7	Ca^{2+}	mg/l	0-20	30	29	53	32
8	Mg^{2+}	mg/l	0-5	29	6	3	21
9	NBO_5	mg/l	0-18	7.37	2.8194	4.829	7.5
10	Cl^-	mg/l	0-30	56.8	56.8	31.95	58.2
11	Nitrite (NO_2—N)	mg/l	0-0.3	1.32	1.45	1.03	0,04
12	NO_3-	mg/l	0-5	1.57	1.62	1.36	1.64
13	PO_4^{3-}	mg/l	0-0.5	0.05	0.062	0.044	0,065
14	Total Phosphorus	mg/l	0-1	0.045	0.051	0.041	1.7
15	Acidity	log (H+)	6.0-8.5	7.94	7.94	7.85	7.93

Physical analyses of the Dunavec river water, carried out throughout the irrigation season, based on standard methods, are presented in Table 5.

Based on the analysis data, it results that the waters of the Dunavec River are within the permitted norms in terms of the indicators Biochemical need for oxygen (NBO_5), the content of nitrates NO_3, Total Phosphorus, and Acidity.

The chemical oxygen demand (COD) is above the allowed rates in the main irrigation season in the months of July-August. Total Alkalinity is slightly higher than the allowed rates. Chlorine Cl^- is present approximately at the allowed rates, and this is explained by the operation of the plant for the treatment of polluted water in the city of Korce, as well as a larger number of villages that pour polluted water into the Dunavec river. The content of Ca^{2+}, Mg^{2+} was found to exceed the allowed rates.

Table 5. Values of water indicators 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	Temperature	°C	>16	18	17	15
2	Total Dissolved Solids	mg/l	0 – 2000	60	40.4	19.8
3	Dry residue	mg/l	0 – 2000	328	330	325
4	Total Alkalinity	mg/l	0-250	322	300	316
5	COD	mg/l	4-7	23	11.5	3
6	Ca^{2+}	mg/l	0-20	24.4	24.6	40
7	Mg^{2+}	mg/l	0-5	20.9	36.4	15
8	NBO_5	mg/l	0-18	3.72	2.4	1.9
9	Cl^-	mg/l	0-30	35.5	21.3	30.4
10	Nitrite (NO_2—N)	mg/l	0-0.3	1.65	1.96	1.44
11	NO_3-	mg/l	0-5	1.88	1.99	1.67
12	PO_4^{3-}	mg/l	0-0.5	0,7	1.4	0.6
13	Total Phosphorus	mg/l	0-1	0.7	1	0.5
14	Acidity	log (H+)	6.0-8.5	7.87	8	8.03

Discussion

The results of the study reflect the quality of river waters used for irrigation of the Korça field, as well as the factors that affect their pollution.

The main factors for increasing the concentration of Ca^{2+} and Mg^{2+} in rivers are determined as natural factors, related to the geological structure of the river catchment area, and anthropogenic influence, such as land use and sewage flows (Potasznik & Szymczyk, 2015).

Chlorine (Cl^-) is an anion that is found in all natural waters. Abnormally high concentrations serve as "early warning" indicators of the presence of other, more toxic pollutants (Kelly et al., 2012). Excess chloride can cause chloride toxicity in plants. A chloride concentration of about 140 - 350 mg/l in irrigation water is harmful to plants (Mass, 1990).

Concerns are raised by the content above the permissible norms of Nitrite NO_2^- and Orthophosphate PO_4^{3-}. The high presence of these ions is related to the pollution of the waters of this river by human activity. Pollution with mobile forms of nitrogen (N) and phosphorus (P) is one of the most problematic because it causes eutrophication. N and P are related to agricultural activities and are considered non-point source pollutants. The main sources of nitrogen in water are sewage, industrial waters, the use of fertilizers for the growth of crops, some of which pass into rivers through rainfall or irrigation. Nitrogen in water is oxidized to nitrites (NO_2^-). Bacteria convert nitrites into nitrates (NO_3^-) through a process that binds the available oxygen in the water. The highest nitrate levels are observed after heavy rainfall.

In addition to the impact of sewage, industrial runoff and fertilizer use on land, an additional source comes as a result of the decomposition of organic pesticides containing phosphorus. The highest levels of phosphates and phosphorus are observed after heavy rainfall (Sulaiman et al., 2014).

River flow obtains oxygen from the atmosphere and plants as a result of photosynthesis. Running water gets more oxygen than calm water. Aquatic animals consume oxygen through respiration, various chemical reactions and decomposition. Wastewater contains organic materials that are decomposed by microorganisms, which use oxygen in the process (Anh et al., 2023). Therefore, the two indicators, Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (NBO_5), easily serve to evaluate the quality of river waters.

The content above the permissible levels of Cl^- and Mg^{2+} leads to the destruction of soil structural aggregates, reduces soil fertility and causes plant toxicity (Geilfus, 2019; Latifi et al., 2016).

Different crops show different reactions to different indicators of water quality. According to Ayers & Westcot (1994), of the crops cultivated in this area, barley, maize, wheat, and sugar beet are plants more resistant to salinization, alfalfa, melon, lettuce are moderately resistant plants and beans, onions, and tomatoes are sensitive plants. The irrigation method has a significant impact on both the efficiency of water use and the way of salts are collected.

Conclusions

The water of the Devolli River turned out to be of good quality for irrigation in terms of indicators of Biochemical Need for Oxygen (NBO_5), Nitrites (NO_2-N), nitrates NO_3^-, phosphates PO_4^{3-}, Total Phosphorus, and acidity. The content of Cl^-, Ca^{2+} and Mg^{2+} is above the permissible limits. The high presence of these ions is related to the pollution of the waters of this river by human activity. Taking into account the totality of the analyzed factors, it is classified as Good Condition Cl.II.

The waters of the Dunavec River are presented within the permissible standards for indicators, Biochemical need for oxygen (NBO_5), the content of nitrates NO_3^-, Total Phosphorus, and Acidity.

The chemical oxygen demand (COD) is above the permissible limits during the main irrigation season in the months of July-August. Total Alkalinity is slightly higher than the allowed rates. Chlorine Cl^- appears approximately in the allowed rates, and this is explained by the operation of the wastewater treatment plant in the city of Korce. The content of Ca^{2+} and Mg^{2+} is presented above the allowed rates. Concerns are the content above the allowed rates of Nitrites NO_2^- and Orthophosphate PO_4^{3-}. The high presence of these ions is related to the pollution of the river waters by human activity, such as irrigation, chemical and organic fertilizers use in agriculture, etc. Taking into account the totality of the analyzed factors, it is classified as Moderate Condition Cl. III.

The lack of sewage facilities is an important factor in the pollution of the environment in general and river water in particular. Environmentally friendly practices such as irrigation, fertilization, and pesticide use, are factors that need to be addressed.

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