THE IMPACT OF ANTHROPOGENIC FACTORS ON THE QUALITY OF SURFACE AND GROUNDWATER: A CASE STUDY OF SELECTED SETTLEMENTS IN BAČKA

AnitaPetrović[1] Jovan Pavlović [2]Petra Tanović[3]

Abstract: Water pollution has been a concern of professional and scientific communities in our country for several decades. However, despite extensive attention, efforts to mitigate the issue remain insufficient. Continuous pollution, the depletion of water resources, and the impacts of climate change have placed Vojvodina at risk of a drinking water shortage. This study aims to evaluate the quality of water available to residents of Gajdobra and Maglić in their households, as well as the quality of surface water bodies used for recreational fishing and irrigation. Such research is particularly significant for residents of smaller settlements, who often lack information about the quality of the water they consume and are unaware of the potential health risks associated with its use.

Key words: drinking water, surface water, quality control

1. INTRODUCTION

It is common knowledge that water is one of the key resources of the 21st century.
This is due to the increasing global population, as well as the rising demand for water resulting from higher living standards, changes in lifestyles, and the expansion of industrial and agricultural production. Consequently, global water consumption is continually growing.

Annual global water consumption is estimated to be around 800 m³ per person, with the highest per capita water usage in the United States at 3,000 liters per person per day. In contrast, consumption in underdeveloped countries is 100 times lower. [1]

Additionally, there is a persistent trend of population concentration in large cities, causing two major challenges:

- The need to supply large quantities of drinking water in relatively small areas.
- Transforming all that water into polluted wastewater, which is then treated to varying degrees and discharged into the environment, thereby endangering the remaining clean water reserves. [1]

Almost all industries and agriculture significantly consume and pollute water. In Vojvodina, where the water samples were collected, the food industry dominates, both in terms of the number of enterprises and the value of their products. However, food production, alongside related activities, substantially alters the Earth's biosphere and significantly contributes to increased pollution and changes in physical-chemical properties.

The main sources of pollution from agricultural land are:

- Use of mineral fertilizers,
- Application of pesticides,
- Depletion of natural nutrients and fertilizers in the soil,
- Accumulation of salts and minerals due to irrigation,

[1]PhD, Professor of applied studies, Higher Education Technical School of Professional Studies, Školska 1, Novi Sad, Serbia, email: petrovic.a@vtsns.edu.rs
[2]
[3]PhD, Professor of applied studies, Higher Education Technical School of Professional Studies, Školska 1, Novi Sad, Serbia, email: tanovic@vtsns.edu.rs

- Disposal of manure, and
- Disposal of agricultural waste and food production residues. [1]

The primary components of mineral fertilizers include phosphates and nitrates as anions, potassium and ammonium ions as cations, and urea, which is in molecular form at the time of application. Unused amounts of mineral fertilizers remain partly in the soil and partly seep into water bodies.

The use of pesticides is driven by the goal of increasing food production efficiency, primarily by combating various harmful organisms that reduce crop yields. A wide range of pesticides is used, with about 50 being the most common. Pollution sources include agricultural lands, urban areas treated for mosquito control, and other sanitary measures aimed at disease prevention. Numerous studies have confirmed their toxic effects on humans and other organisms.

In water pollution, the most dangerous aspect of pesticides is their accumulation in the food chain and their role in disrupting ecosystems.

The quality of surface and even groundwater in Vojvodina is poor.
Residents of 20 municipalities in Vojvodina consume unsafe drinking water, with the situation being particularly severe in Banat. Drinking water frequently exhibits elevated concentrations of iron, manganese, nitrites, and nitrates, along with consistently high levels of chemical oxygen demand, indicating general pollution. Arsenic is also a persistent issue; however, this study does not address it. The most common problems in drinking water are a combination of physicochemical and microbiological deficiencies.

Most surface and groundwater in Vojvodina is classified as second or third quality class, with significant issues arising from the Danube–Tisza–Danube canal system, as well as secondary irrigation and transport channels.

Groundwater remains Vojvodina's last acceptable resource; however, its levels have been receding in recent decades due to overuse and climate change, making it unsuitable for technological applications.

A particular problem contributing to cumulative pollution is the lack of wastewater management. Across Vojvodina, 511 water polluters have been identified, including:

- 326 industrial polluters,
- 121 agricultural and livestock polluters,
- 44 settlements, and
- 20 others.

Additionally, 60% of the population is not connected to public sewage systems. [2]

The aim of this paper is to examine the quality of drinking water from the waterworks in Maglić and the well in Gajdobra as a representation of the state of drinking water in Bačka. The quality of surface water at the same location was examined and this is also presented in the paper.

2. EXPERIMENTAL SECTION

Water sampling was conducted to assess the quality degradation of both surface and groundwater in the area surrounding Gajdobra and Maglić due to agricultural activities and chemical treatments.

Drinking water samples were collected from the village water supply in Maglić and from an underground pipe well in Gajdobra to represent the state of drinking water.

Additionally, surface water samples were taken from a lake in Maglić and the Danube–Tisza–Danube (DTD) canal**.**

In this study, several key physicochemical parameters relevant to the quality of the sampled water were analyzed. The tests were carried out in the laboratory of the Higher Technical School of Professional Studies in Novi Sad.

Figure 1 illustrates the area where the sampling was conducted.

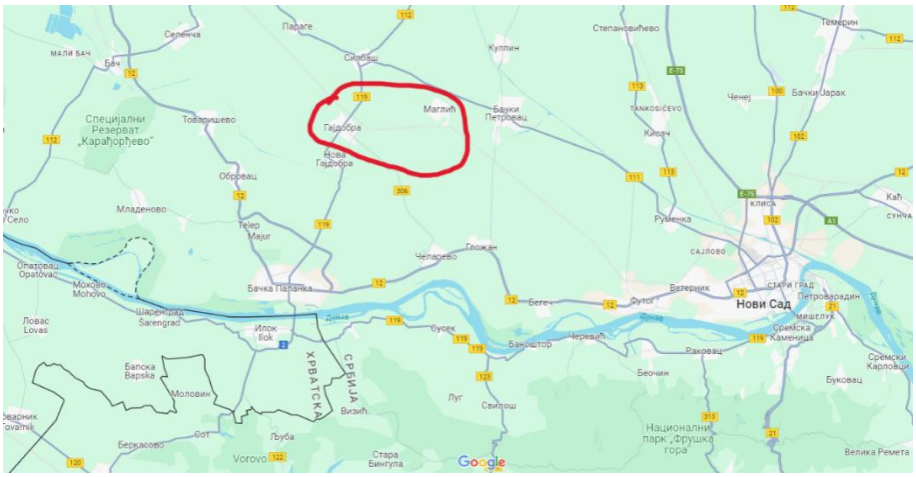

Figure 1 – The area between the villages of Maglić and Gajdobra where water sampling was conducted

Given that the consumption of water from the Maglić water supply has not been recommended for years, an analysis of the parameters listed in Table 1 was conducted.

Table 1 - Results of the analysis of water from the Maglić water supply.

Sample: Water from the Maglić water supply	**Results**	**Maximum value for the class**
pH	*9,32*	*6,8 – 8,5*
Electrical Conductivity	*1.200 [µS/cm]*	*do 1.000 [µS/cm]*
COD (from $KMnO_4$) (Chemical Oxygen Demand measured using potassium permanganate)	*11,3 [mg/dm^3]*	*do 8 [mg/dm^3]*

Hardness - $CaCO_3$	*41 [mg/dm^3]*	
Chlorides - Cl^-	*28 [mg/dm^3]*	*200 [mg/dm3]*
Nitrates - NO_3^-	*45 [mg/dm^3]*	*50 [mg/dm^3]*
N from NO_3^-	*10,2 [mg/dm^3]*	*50 [mg/dm3]*
Nitrites - NO_2^-	*0,03 [mg/dm^3]*	*0,03 [mg/dm^3]*
N from NO_2^-	*0,01 [mg/dm^3]*	*0,03 [mg/dm3]*
Cu – Free (Free Copper)	*0,05 [mg/dm^3]*	*2 [mg/dm3]*
Cu – Total (Total Copper)	*0,32 [mg/dm^3]*	
Cu – Combined (Combined Copper)	*0,05 [mg/dm^3]*	
Iron – Fe	*0,02 [mg/dm^3]*	*0,3 [mg/dm^3]*
SO_3^{-2}	*0,1 [mg/dm^3]*	
SO_4^{-2}	*5 [mg/dm^3]*	

Table 2 shows systematized results of water analysis from the well in the village of Gajdobra.

Table 2 - Results of the analysis of well water in the village of Gajdobra.

Sample: Well	**Results**	**Maximum value for the class**
pH	*7,49*	*6,8 – 8,5*
Chlorides - Cl^-	*27,8 [mg/dm^3]*	*200 [mg/dm3]*
Conductivity	*1.150 [µS/cm]*	*do 1.000 [µS/cm]*
COD (from $KMnO_4$)	*4 [mg/dm^3]*	*do 8 [mg/dm^3]*
Hardness - $CaCO_3$	*4 [mg/dm^3]*	
Nitrates - NO_3^-	*45[mg/dm^3]*	*50 [mg/dm3]*
Nitrites - NO_2^-	*0,01[mg/dm^3]*	*0,03 [mg/dm^3]*
Cu – Total (Total Copper)	*0,32[mg/dm^3]*	

The lake in Maglić is a small artificial lake rich in fish. The results of the analysis are presented in the following table.

Table 3 - Results of the analysis of lake water in the village of Maglić.

Sample: Lake	Results	Maximum value for the class	Class
pH	*7,70*	*6,8 – 8,5*	1
Chlorides - Cl^-	*14,3 [mg/dm^3]*	*100 [mg/dm3]*	2
Conductivity	*700 [µS/cm]*	*600 – 800 [µS/cm]*	3
COD (from $KMnO_4$)	*9,35 [mg/dm^3]*	*6 – 10 [mg/dm^3]*	2
Hardness - $CaCO_3$	*141 [mg/dm^3]*	*160 – 140 [mg/dm^3]*	2
Nitrates - NO_3^-	*3,4 [mg/dm^3]*	*1,0 – 5,0 [mg/dm^3]*	2
Nitrites - NO_2^-	*0,3 [mg/dm^3]*	*0,05 – 0,5 [mg/dm^3]*	3
Cu – Total (Total Copper)	*0,42 [mg/dm^3]*	*< 5 [mg/m3]*	1
Fe – Total (Total Iron)	*0,01 [mg/dm^3]*	*< 100 [mg/dm^3]*	1

The Danube–Tisza–Danube (DTD) hydrosystem is a unique canal network connecting the Danube and Tisza rivers through Vojvodina. It serves as a hydrotechnical system for drainage of internal waters, irrigation, flood defense, water supply, wastewater discharge, navigation, tourism, fishing, and forestry.

Fishing is possible on the DTD canal; however, a decline in the carp population has been observed, while populations of invasive, disease-resistant species (such as crucian carp and American channel catfish) have increased.

The results of the water analysis from the DTD canal, conducted at the locality near the bridge on the main road between Gajdobra and Čelarevo, are presented in Table 4.

Table 4 - Results of the analysis of water from the DTD canal.

Sample: DTD Canal	Results	Maximum value for the class	Class
pH	*7,46*	*6,8 – 8,5*	1
Chlorides - Cl^-	*57 [mg/dm^3]*	*100 [mg/dm3]*	2
Conductivity	*400 [µS/cm]*	*400 – 600 [µS/cm]*	2
COD (from $KMnO_4$)	*9 [mg/dm^3]*	*6 – 10 [mg/dm^3]*	2
Hardness - $CaCO_3$	*153 [mg/dm^3]*	*160 – 140 [mg/dm^3]*	2
Nitrates - NO_3^-	*4 [mg/dm^3]*	*1,0 – 5,0 [mg/dm^3]*	2

Nitrites - NO_2^-	*0,14 [mg/dm^3]*	*0,05 – 0,5 [mg/dm^3]*	3
Cu – Total (Total Copper)	*0,38 [mg/dm^3]*	*< 5 [mg/m3]*	1
Iron - Fe	*0,02 [mg/dm^3]*	*< 100 [mg/dm^3]*	1

3. RESULTS AND DISCUSSION

The status of the obtained parameters, and their acceptability in water, is defined by the Regulation on Hygienic Safety of Drinking Water ("Official Gazette of the FRY," nos. 42/98 and 44/99, and "Official Gazette of RS," no. 28/2019) and the Regulation on Parameters for the Ecological and Chemical Status of Surface Waters and the Chemical and Quantitative Status of Groundwater ("Official Gazette," no. 74/2011). [3], [4]

From the measurements presented in the previous section, the following observations can be made:

- Maglić water supply:
  The water in the Maglić water supply system is sourced from a pumping station near the village, drawing water from a depth of 84 meters. Organoleptic tests indicate the water has a yellowish color, with no discernible odor or taste. The main issue is the pipeline, which has not been repaired for years, as well as abandoned old houses where metal pipes have corroded due to lack of use.
- Well in Gajdobra:
  The well in Gajdobra is drilled to a depth of 87 meters. The water is relatively clear, tasteless, and has a rotten egg smell, indicating the presence of hydrogen sulfide. This water is not used for drinking but serves for garden irrigation and livestock watering.
- Lake in Maglić:
  The lake was previously a dumping site for construction debris. By order of the Bački Petrovac municipality, the site was cleaned, and a lake was created and stocked with carp, white fish, and predatory species such as pike and catfish. Swimming is prohibited, but fishing is allowed. The fish population is active, abundant, and of high quality. The water appears greenish and odorless, with no visible signs of algae bloom.
- DTD Canal:
  The canal water has a greenish color and a slight smell of silt. Submerged vegetation has proliferated, making fishing difficult in the summer months due to limited accessibility.

4. CONCLUSION

In conclusion, the following findings can be highlighted:

- Water from the Maglić water supply:
  The chemical oxygen demand (COD) is 30% above the admissible limit, making the water completely unsuitable for drinking according to legal standards. Despite this, it serves a population of nearly 3,000 people. Nitrate levels at 45 mg/dm³ and carcinogenic nitrite levels at 0.03 mg/dm³ are at the threshold of acceptability, indicating contamination of the groundwater source with fecal pollutants.

- Well water in Gajdobra:
  The sampled well water also shows elevated concentrations of nitrates and nitrites near the permissible limits. However, the COD was within acceptable boundaries.
- Lake water in Maglić:
  The water quality of the artificial lake in Maglić generally falls into Class 2, except for conductivity and nitrate levels, which belong to Class 3.
- DTD Canal water:
  The water at the selected location was of adequate quality, except for nitrites, with a concentration of 0.14 mg/dm³, which is acceptable for Class 3 water.

General observations:

The quality of the analyzed water, as presented in the tables, indicates that the water quality is unsatisfactory due to parameters exceeding the permissible limits. However, it is encouraging that aquatic life in surface waters continues to function despite the deteriorated water quality.

5. REFERENCES

[1] Petrović-Gegić, A., Božović, T.: *Pollution and Water Protection*, Higher Technical School of Professional Studies in Novi Sad, 2020.
[2] https://vodevojvodine.com/o-nama/delatnosti/zagadjivaci/
[3] Regulation on Hygienic Safety of Drinking Water ("Official Gazette of the FRY," nos. 42/98 and 44/99, and "Official Gazette of RS," no. 28/2019).
[4] Regulation on Parameters for the Ecological and Chemical Status of Surface Waters and Parameters for the Chemical and Quantitative Status of Groundwater ("Official Gazette," no. 74/2011).