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Maja Petrović

Ivana Mihajlović

Nevena Živančev

Bojana Zoraja

Tijana Adamov

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PREFACE

With great pleasure, I extend warm greetings on behalf of the Scientific and Organizing Committees. It is an honor to introduce the Proceedings of the 1st International EUROSA Conference held from September 12 – 15, 2023, in Brzeće, Kopaonik, Serbia.

This compilation represents the culmination of dedicated efforts and scholarly contributions from our esteemed participants. The papers contained herein encapsulate a wealth of knowledge and innovation in the field of sustainable management of occupational health and safety, environmental protection, fire protection and emergency situations. They reflect the collective efforts of researchers, academics, and professionals who have generously shared their insights during the conference.

Our sincere gratitude goes to all contributors for enriching the conference and ensuring its success. Special appreciation is extended to all participants of the Roundtable and Panel Discussions. Special thanks are also due to our esteemed keynote speakers, session chairs, and reviewers for their invaluable contributions.

As we reflect on the insights shared during the conference, we recognize the power in connecting the academic community and the business sector. This synergy provided a platform for exploring significant achievements, the latest trends, and the exchange of practical experiences and best practices in the mentioned fields.

I would like to express my sincere thanks to all members of Scientific and Organizing committees, whose planning and execution were instrumental in ensuring the Conference's success.

Confident that the solid foundation created by the 1st International EUROSA Conference will continue to build up and strengthen the unique international network of academics and professionals, we present these proceedings as a lasting resource. May the papers herein inspire continued dialogue and exploration in the field of sustainable management of occupational health and safety, environmental protection, fire protection and emergency situations.

Editor

In Novi Sad, September 2023 — Dr. Maja Petrović

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ASSESSMENT OF AQUATIC ENVIRONMENTAL PARAMETERS AND IDENTIFICATION OF SOURCES OF POLLUTION

Perović M.[1], *Obradović V.*[1], *Milovanović M.*[1], *Sretenović Ž.*[1]

[1] Jaroslav Černi Water Institute, Jaroslava Černog 80, 11 226 Belgrade, Republic of Serbia (e-mail: marija.perovic@jcerni.rs)

Abstract: Water quality is a complex issue impacted by natural conditions and anthropogenic activities. It is usually reported based on simultaneous chemical, physical, and biological analysis of results. The utilization of water and environmental protection of this valuable resource will greatly depend on water composition. Presented research included monthly measurements of 19 physicochemical parameters of water quality, during a 5-year period, from an official state monitoring program, for two profiles on the Danube in Serbia. The aim of the research was determination of the relations between examined parameters, and their analysis in the light of tracing the potential signature of anthropogenic impact on water quality. The analysis of the results confirmed that the distance from the pollution source and the accompanying dilution have a significant influence on the concentration levels of the observed parameters. Without measured significant variations in parameter concentrations only an indication of the pollution origin can be designated.

Keywords: *water quality; PCA analysis; sewage.*

INTRODUCTION

Surface water quality is influenced by atmospheric precipitation (water level), deposition, soil erosion (geology), population, industrialization in the basin area, seasonal change in temperature, and mixing of different types of water (Matijević et al., 2015). Point pollution sources are characterized by an exact location of wastewater discharge, while diffuse or nonpoint sources are generated spatially and are harder to control. Population connected to sewage and industrial plants represent the most significant point sources of pollution. Diffuse pollution sources include all surface and underground polluting substances loads that directly or indirectly reach watercourses, originating from the population that is not connected to the sewage system, inadequate land cultivation and leaching from forest and soil surfaces (due to inadequate soil management), livestock, non-sanitary landfills, and others human activities (WMS, 2017). According to the WMS, 2017, the current state of water quality protection in Serbia is primarily the result of a lack of funding, specifically for the construction and ongoing maintenance of wastewater treatment plants for settlements as well as for industrial and other consumers. Almost 75% of the population of the Republic of Serbia lives in settlements larger than 2,000 inhabitants, in which the average connection to public sewage systems is about 72%, and on individual (septic tanks) about 27%. In settlements with less than 2,000 inhabitants, the connection to the sewage system is less than 5% (WMS, 2017).

More than 50 wastewater treatment facilities, 32 of which are now in use, have been built in settlements with more than 2,000 residents in the Republic of Serbia over the previous few decades. Few operate in accordance with project requirements, while the majority perform with productivity significantly below projected. Although most of the City of Belgrade's sewage infrastructure has been constructed, the problem of wastewater evacuation and treatment has not yet been properly solved. The Belgrade Sewerage System is partitioned into five distinct catchment areas, and systems: Central, Batajnica, Banat, Ostružnica, and Boleč. Among these, the largest is the Belgrade Central Sewerage System, covering approximately 85% of the entire Belgrade Sewerage System (Mitrinović et al., 2022). This system serves around 1,250,000 residents who are connected to the sewage network. Through more than 40 direct sewage outfalls, all effluent is released without treatment into the Sava River and Danube River (Mitrinović et al., 2022).

The largest sewage outfalls are: „Sajam", „Ušće", „Lasta", „Dorćol", „Istovarište", „Ada Huja 1", „Ada Huja 2", "Mirijevski potok" „Višnjica" and "Karađorđev Trg". Wastewater quantity and quality data obtained from measurements conducted at these outfalls are presented in Table 1 (2010-2019) (JCWI, 2020). There is no recorded measurement data at the outfall location "Mirijevski Potok".

Table 1. Average wastewater quantity and quality values in the period from 2010 to 2019 (JCWI, 2020)

Outfall	$Q_{avg.dly}$	BOD_5	COD	TSS	TN	TP	PE	PE
	l/s	mg/L	mg/L	mg/L	mg/L	mg/L	(BOD_5)	(COD)
Sajam	1480	240	361	200	31	4	511 084	384 410
Ušće	667	224	348	257	42	5	215 097	166 963
Lasta	280	195	296	165	28	6	78 700	59 581
Dorćol	152	147	239.5	107	25	5	32 150	26 216
Istovarište	530	173	268	142	31	7	131 752	102 211
Ada Huja 1	35	182	285	309	24	3	9 179	7 172
Ada Huja 2	28	157	255	191	22	5	5 202	4 226
Višnjica	117	212	316	228	36	7	53 969	40 231
Karađorđev Trg	305	215	323	165	40	7	94 544	71 022

According to the construction of the sewage infrastructure, the Republic of Serbia belongs to the group of medium-developed countries, while in terms of wastewater treatment, the very back. The sewage network covers about 55% of the population, while less than 10% of the population is covered by some level of wastewater treatment (WMS, 2017). The few industries have pretreatment of technological wastewater, before entering the sewage network or other recipients. In addition to the above, the water quality of major watercourses on the territory of the Republic of Serbia is threatened by most parameters of water quality (WMS, 2017).

Figure 1 shows the spatial distribution of hydrological stations, sanitary and combined sewer outfalls, and analyzed (sampled) profiles in the area of interest.

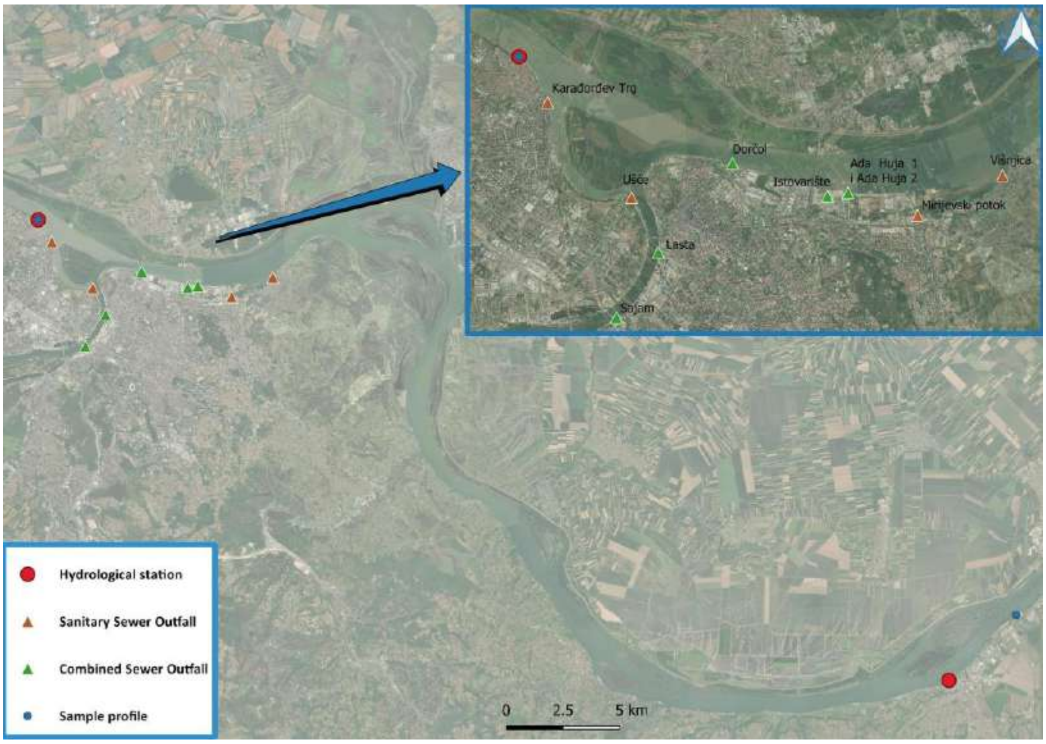

Figure 1. Spatial distribution of hydrological stations, sanitary and combined sewer outfalls, and analyzed (sampled) profiles in the area of interest

According to the quality of surface water bodies from the WMS, 2017, the largest number of water bodies in Serbia belong to the II and III quality class (over 80% of monitored water bodies), while less than 20% of water bodies belong to IV and V quality classes. It is also stated that water bodies on large watercourses, Danube, Tisza, Sava, and Drina, meet the criteria for class II quality, except for the content of orthophosphate in the exit sector of the Danube, which belongs to class III (WMS, 2017). In general, it can be concluded that surface water quality is relatively good, given the fact that less than 10% of wastewater is treated in an adequate way. It is particularly significant that the water quality of the Danube River at the exit from the Republic of Serbia is significantly better than the quality at the entrance, indicating the quality improvement throughout its course throughout the country (WMS, 2017).

MATERIALS AND METHOD

The results of the quality of the surface water body in the territory of AP Vojvodina Danube - Zemun (water body D6 - Accumulation of HPP Đerdap 1 - from the mouth of the Sava to the mouth of the Tisa) were compared with the water quality in the profile Danube near Smederevo (water body D5-Accumulation of HPP Đerdap 1 - from the mouth of the Velika Morava to the mouth of the Sava), analyzed and interpreted. The first sampled profile Zemun is located on the Danube, roughly 1 km upstream of the first bigger outfall of the Belgrade Sewer System, - "Karađorđev trg. The second analyzed profile is located near Smederevo, about 45 km downstream from the last major outfall of the Belgrade Sewage System into the Danube River - "Višnjica". It is also important to note that water levels have been used for the following analysis since the downstream hydropower plant Iron Gate 1 has a great impact on the reliability of the daily flow measurements. The average flow of the Danube River during the 5-year period of interest at profile Zemun was around 3250 m^3/s and at profile Smederevo was around 4600 m^3/s.

The application of statistical processing methods is common for large data sets of monitoring results. The statistical data processing of selected water quality parameters was conducted with the aim of revealing the hidden relations, which might indicate possible pollution sources. Analyzed data originate from annual surface and groundwater quality monitoring reports, created by the Ministry of Environmental Protection for the period 2017-2021. The applied principal component analysis (PCA) is a statistical technique for reducing the dimensionality of a dataset while increasing the interpretability of data and preserving the maximum amount of information. It is important to emphasize that PCA results depend on parameters included in the analysis. The basic descriptive statistics for profile Zemun are presented in Table 2.

Table 2. Descriptive statistic of selected parameters for profile Zemun

		pH	Ec	NH_4^+	NO_2^-	NO_3^-	BOD	TOC
N	Valid	60	60	60	60	60	59	44
	Missing	8	8	8	8	8	9	24
Unit		/	µS/cm	mgN/l	mgN/l	mgN/l	mg/l	mg/l
Mean		8.04	393.4	0.17	0.014	0.98	2.38	4.08
Median		8.04	390.5	0.16	0.011	0.90	2.30	3.90
Std. Deviation		0.21	51.5	0.08	0.01	0.33	0.77	1.21
Minimum		7.58	305.0	<0.02	0.01	0.50	1.10	2.10
Maximum		8.45	516.0	0.31	0.07	1.90	5.30	6.60
Percentiles	25	7.91	348.0	0.12	0.010	0.70	2.00	3.03
	50	8.04	390.5	0.16	0.011	0.90	2.30	3.90
	75	8.17	435.5	0.23	0.016	1.20	2.80	5.07

The basic descriptive statistics for profile Smederevo are presented in Table 3.

The analyzed parameters were chosen because their correlations can indicate the origin of the pollution or indicate the unfolding of the transformation process. The parameters processed by statistical data processing included water level, turbidity, suspended solids, pH value, electrical conductivity (Ec), ammonium ion (NH_4), nitrites (NO_2), nitrates (NO_3), organic nitrogen (ON), total nitrogen (TN), orthophosphates (OP), total phosphorous (P), sodium (Na), chloride (Cl), sulfates (SO_4), boron (B), chemical oxygen demand (COD), biological oxygen demand (BOD) and total organic carbon (TOC). The program IBM SPSS Statistics v.23 was applied. The Rotation Method Varimax with Kaiser Normalization was implemented and the obtained value for Bartlett's test of sphericity $p < 0.01$ indicates that factor analysis can provide significant information for data interpretation. Based on eigenvalues greater than 1, PCA analysis revealed four factors in the Zemun profile (Principal components - PCs) which explain 82.75% of the total variance, and four factors in the Smederevo profile that explain 93.52% of total variance.

Table 3. Descriptive statistics of selected parameters for profile Smederevo

		pH	Ec	NH_4^+	NO_2^-	NO_3^-	BOD	TOC
N	Valid	60	60	60	60	60	57	31
	Missing	5	5	5	5	5	8	34
Unit		/	µS/cm	mgN/l	mgN/l	mgN/l	mg/l	mg/l
Mean		7.99	390.7	0.16	0.012	0.83	2.12	3.59
Median		8.01	385.0	0.15	0.011	0.80	2.00	3.60
Std. Deviation		0.19	38.2	0.07	0.005	0.21	0.62	0.79
Minimum		7.51	328.0	<0.02	0.004	0.40	1.00	1.90
Maximum		8.46	499.0	0.30	0.03	1.40	3.90	5.20
Percentiles	25	7.86	360.3	0.12	0.009	0.70	1.70	2.90
	50	8.01	385.0	0.15	0.011	0.80	2.00	3.60
	75	8.10	412.8	0.22	0.015	0.98	2.55	4.00

RESULTS AND DISCUSSION

Zemun profile

For the first examined profile Zemun, the PCA revealed four principal components, which explain 82.75 % of the total variance (Table 4.). Because of their significance, the first two components are further analyzed. The hydrochemical factors of point pollution (phosphorous, ammonium ion, and conductivity) are in inverse correlation with the water level, pH value, BOD, and TOC. PC2 explains 22.44% of the total variance and shows that in examined samples increase in turbidity is followed by an increase of suspended solids, nitrite, nitrate, organic, and total nitrogen content. At the same time, within the same PC2, the decrease of sodium and chloride (municipal pollution indicators) is noted. Observed positive correlation of nitrogen component with turbidity and suspended solids, and at the same time inverse correlation with sodium and chlorides, indicate that at Zemun profile nitrogen component load is also related to diffuse pollution sources probably originating from agriculture. Ammonia decrease can be induced by the nitrification process, where generated nitrates, along with phosphorous, could be assimilated by the aquatic plant component (macrophyte vegetation and algal production-organic production) whose indirect indicator is the increased pH value and increased organic carbon content. The confirmation of the mentioned can be inferred from the ammonia and phosphorous simultaneous decrease, followed by pH, TOC, and BOD increase, observed within the PC1 on the Zemun profile.

Smederevo profile

For the second profile Smederevo downstream from Belgrade, the PCA revealed four factors that explained 93.52% of the total variance (Table 4). Because of their significance, PC1 and PC2 are further discussed. The PC1 explains 34.18% of the variance and shows a significant relation between water level, turbidity, suspended solids, pH, and TOC. Within the same factor (PC1) the decrease of conductivity, nitrates, sodium, chloride, and sulfate concentration is noticed.

The influence of hydrological conditions (water level) on water quality can be observed from PC1, as well as an indication that organic pollution (probably of autochthonous origin - algae biomass) near Smederevo depends on the water level of the river, which can be indicated by measured pH values. The indicators of communal pollution (sodium, chlorides, sulfates, and nitrates), at this profile, are in negative correlation with the river water level indicating dilution influence. The second factor (PC2) explained 26.08% of the total variance and showed a significant relationship between ammonium, nitrites, organic nitrogen, total nitrogen, and orthophosphate. Within the same factor, the inverse correlation with organic pollution (chemical and biological oxygen demand) is observed, which indicates that the nitrogen component probably originates from mineral fertilizers, erosion, or surface runoff.

Table 4. Component matrix for examined profiles

	Principal Components Zemun			
	PC1	PC2	PC3	PC4
Water level	0.758			
Turbidity		0.769		
Suspended solids		0.597	-0.625	
pH	0.823			
Ec	-0.742			
NH_4	-0.720			
NO_2		0.612		
NO_3		0.504	0.588	
ON		0.638		
TN		0.826	0.511	
OP				0.592
P	-0.702		0.533	
Na	0.646	-0.706		
Cl		-0.671		
SO_4	-0.847			
B	0.620			
COD				0.693
BOD	0.579			0.636
TOC	0.731			

	Principal Components Smederevo			
	PC1	PC2	PC3	PC4
Water level	0.791			
Turbidity	0.744			
Suspended solids	0.863			
pH	0.534			-0.837
Ec	-0.763			0.537
NH_4		0.548	-0.763	
NO_2		0.926		
NO_3	-0.597			-0.518
ON		0.760		
TN		0.880		
OP		0.916		
P			-0.842	
Na	-0.752			
Cl	-0.831			
SO_4	-0.765		-0.546	
B			0.985	
COD		-0.766		
BOD		-0.579	0.758	
TOC	0.961			

CONCLUSION

Surface water monitoring is an important tool for maintaining ecosystems, protecting public health, ensuring sustainable resource management, and responding to environmental challenges. It enables making adequate decisions and taking appropriate actions to safeguard water resources for current and future generations. When it comes to monitoring programs that are carried out on an annual basis, statistical methods are most often used to process such a large set of data with the aim of identifying possible factors/sources responsible for water quality variability. The location and distance of pollution sources from the measuring point, as well as the identification of the other pressures on the water quality, must be considered in the water quality results interpretation.

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