

AGROSYM

BOOK OF PROCEEDINGS



*XV International Scientific Agriculture Symposium
"Agrosym 2024"
Jahorina, October 10-13, 2024*

AgroSym
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**XV International Scientific Agriculture Symposium
“AGROSYM 2024”**



Jahorina, October 10 - 13, 2024

Impressum

XV International Scientific Agriculture Symposium „AGROSYM 2024“

Book of Proceedings Published by

University of East Sarajevo, Faculty of Agriculture, Republic of Srpska, Bosnia
University of Belgrade, Faculty of Agriculture, Serbia
Mediterranean Agronomic Institute of Bari (CIHEAM - IAMB) Italy
International Society of Environment and Rural Development, Japan
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Website:

<http://agrosym.ues.rs.ba>

CIP - Каталогизација у публикацији
Народна и универзитетска библиотека
Републике Српске, Бања Лука

631(082)(0.034.2)

INTERNATIONAL Scientific Agriculture Symposium "AGROSYM"
(15 ; 2024 ; Jahorina)

Book of Proceedings [Електронски извор] / XV International
Scientific Agriculture Symposium "AGROSYM 2024", Jahorina,
October 10 - 13, 2024 ; [editor in chief Dusan Kovacevic]. - Onlajn
izd. - El. zbornik. - East Sarajevo : Faculty of Agriculture, 2024

Системски захтјеви: Нису наведени. - Наћin pristupa (URL):
https://agrosym.ues.rs.ba/article/showpdf/BOOK_OF_PROCEEDINGS_2024_FINAL.pdf. - Ел. публикација у ПДФ формату опсега
1552 стр. - Насл. са насловног екрана. - Опис извора дана
2.12.2024. - Библиографија уз сваки рад. - Регистар.

ISBN 978-99976-816-8-3

COBISS.RS-ID 141807105

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Jahorina, October 10-13, 2024, Bosnia and Herzegovina**

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PREFACE

Dear colleagues,

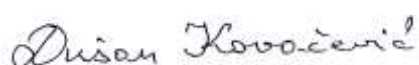
It is with great pleasure that I introduce the *Book of Proceedings* for the 15th International Scientific Agricultural Symposium “AGROSYM 2024.” I trust that you will find it a valuable resource in your work. This year, around 800 contributions have been accepted for inclusion in the *Book of Abstracts*. The themes of AGROSYM 2024 span the full spectrum of agricultural sciences, divided into seven key sessions: 1) Plant Production, 2) Plant Protection and Food Safety, 3) Organic Agriculture, 4) Environmental Protection and Natural Resource Management, 5) Animal Husbandry, 6) Rural Development and Agro-Economy, and 7) Forestry and Agroforestry.

There is growing consensus among scholars and practitioners that technological innovations have the potential to boost agricultural production, enhance supply stability, and reduce the environmental impact of farming. Technology has been especially pivotal in increasing the productivity of annual crops such as maize, rice, soybeans, wheat, and cotton. However, with trees having longer growth cycles, breeding programs for these crops require more time. New plant breeding techniques promise improvements in productivity, but they have sparked an ongoing academic debate regarding their advantages and drawbacks.

While much of the focus in the past has been on the production side of agriculture (e.g., productivity and efficiency), there is an increasing emphasis today on the consumption side and the intermediate stages of the food chain, such as processing and distribution. This shift is driving the transition toward a “farm-to-fork” approach. Globally, consumers are sending clearer signals about their preferences for higher quality, healthier, safer, and more flavorful products. In response, many agri-food companies are exploring innovative ways to gain greater control over production processes and ensure the quality and safety of final products. Furthermore, changes in investment strategies hold the potential to reduce the environmental and social costs of agriculture. It has become increasingly clear to investors that companies that prioritize sustainability and social responsibility tend to yield better long-term returns.

Agri-food systems are at the heart of global discussions surrounding sustainable development and the achievement of the United Nations Sustainable Development Goals (SDGs) by 2030. These systems are deeply connected to numerous global challenges, including climate change, poverty, food insecurity, biodiversity loss, resource depletion, and ecosystem degradation. A key goal of the sustainable agriculture movement is to create farming systems that mitigate or eliminate the environmental harms associated with industrial agriculture. Additionally, it is critical to improve the resilience of food systems to crises, shocks, and pandemics.

I would like to extend my heartfelt thanks to all the authors, reviewers, and colleagues who contributed to the editing of the *Book of Abstracts*. Special thanks are due to our co-organizers and partners for their unwavering collaboration and comprehensive support throughout this endeavor.



East Sarajevo, 10 October 2024

Prof. Dušan Kovačević, PhD

Editor in Chief, President of the Scientific Committee of AGROSYM 2024

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ASSESSING THE INFLUENCE OF NITROGEN PRESSURE ON NITROGEN COMPOUND LEVELS AND COMPOSITION IN SELECTED SURFACE WATER BODIES

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Abstract

With the global population on the rise, there is an increasing demand for food and water, prompting the need for intensified development of modern agricultural practices and proper water management. This population growth leads to higher water consumption and a greater volume of water requiring purification. Consequently, the increased agricultural production and wastewater generation contribute to higher nitrogen compound loads in water bodies. While fertilizer application is crucial for achieving high crop yields and quality products, its inadequate implementation presents various challenges. Moreover, the lack or insufficient functionality of wastewater treatment plants results in a significant amount of untreated wastewater reaching water bodies. This study focuses on investigating the impact of nitrogen compound pressures from various sources on the prevalence of nitrogen compounds in selected surface water bodies. The research aims to assess the extent of nitrogen compound contamination and identify the range of nitrogen compounds present in surface water bodies. By examining their correlation, the origin and transformation processes of nitrogen in the stream can be understood. The findings incorporate data from a five-year monitoring period of two rivers in Serbia – the Sava, and Velika Morava. These results contribute to a better understanding of nitrogen pressures on surface water quality, thus facilitating the development of strategies for sustainable agricultural practices and effective water resource management.

Keywords: *fertilizers, surface water, nitrates, nitrogen transformation.*

Introduction

Damjanović et al. (2001) concluded that non-point sources of pollution contribute to over 50% of total water pollution, as they contribute 90% of fecal and total coliform bacteria, 80% of total nitrogen, and 50% of total phosphorus. From the perspective of Water Framework Directive (WFD), the consequences of excessive use of fertilizers and pesticides, inadequate manure storage, and poor agricultural practices on agricultural land are of particular significance. Agriculture and land use are considered as one of the main drivers of diffuse source pollution emissions into surface and groundwater in the Republic of Serbia (WMP, 2023). Agricultural land covers most of the Serbia's land area (55%) and consequently poses a considerable potential for diffuse pollution, making it one of the major factors contributing to pressures and impacts on surface water and groundwater bodies (WPM, 2023). In addition to agricultural land use, livestock production is also a very important driver of surface and groundwater pollution. An analysis of data from the 2012 Agricultural Census conducted by the Serbian Environmental Protection Agency (SEPA) shows that in 2012, mineral fertilizers were used on 67% of agricultural land, while manure from livestock farms was used on 12% of agricultural land, and 21% of agricultural land was not fertilized. The use of mineral fertilizers in the Republic of Serbia has significantly decreased in the past, from 1,450,000 tons in 1985 to around 300,000 tons in 2000. It is estimated that currently 600,000 tons of

mineral fertilizers are used annually. The average area of total agricultural land per capita, standing at 0.54 hectares, and the utilized agricultural land at 0.48 hectares per capita, highlight Serbia's significantly advantageous position compared to many European countries in this regard. For instance, France has 0.33 ha/cap, Italy 0.2 ha/cap, Germany 0.19 ha/cap, and the Netherlands 0.06 ha/cap. This situation signifies favourable food self-sustainability for the population of Serbia (NRP, 2016). The current agricultural practice regarding manure management is inadequate due to insufficient space for storage on livestock farms and a lack of equipment for its transportation and efficient application in the fields. Livestock contributes to total nitrogen pollution by 71% and about 70% of phosphorus, while households not connected to public sewage contribute to nitrogen pollution by 1.6%, phosphorus by 0.8%, and around 10% organic pollution (WMS, 2023).

Currently, 56% of the total population in Serbia is connected to sewage systems (approximately 3.9 million) (WMP, 2023). Public sewage systems receive about 300,000,000 m³ of wastewater annually. Of the total discharge of wastewater into the public sewage network, 69% comes from households, around 19% from industry, and about 12% from other activities (WMP, 2023). In the Republic of Serbia, 49 wastewater treatment plants have been built. Out of the total number of plants, 32 are operational, with a smaller number achieving the designed effectiveness of the wastewater treatment process. An analysis of nutrient pollution pressures on surface water bodies in the Republic of Serbia is presented in Fig.1.

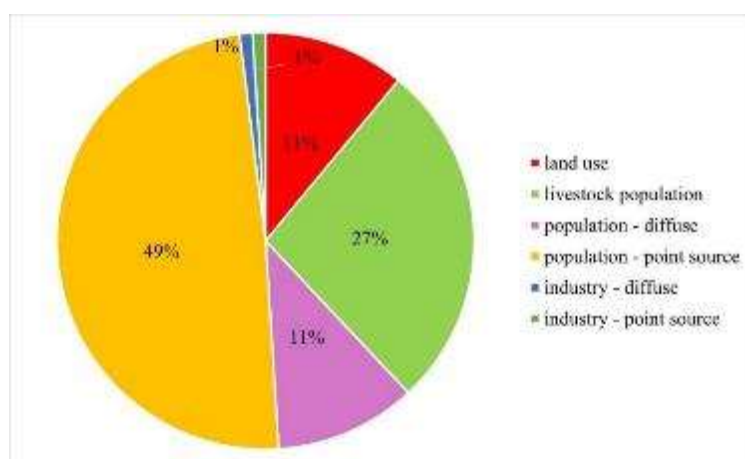


Figure 1. The pressure of nutrients on surface water bodies according to the source of pollution (according to WMS, 2023)

Relatively high specific pressures from nutrient pollution have been identified in less than 15% of the watersheds in the Republic of Serbia. However, it should be noted that even low specific pressures of nutrient pollution can cause significant impacts if the flow of water bodies is low (SUVRs, 2015; WMS, 2023). In conducted research, it was examined whether the current agricultural practice in Serbia and untreated wastewater discharge cause detectable changes in the quality of selected rivers concerning nitrogen compound concentration levels.

Materials and methods

Data from the state monitoring of surface waters (SEPA) have been processed for five-year period (2010-2014). Selected parameters of the Sava River quality are analyzed from 4 profiles: Jamena, Sremska Mitrovica, Šabac, and Ostružnica. The quality of the Velika Morava River is monitored at 5 profiles: Varvarin, Bagrdan, Velika Plana, Trnovče, and Ljubičevski Most. To group variables directly or indirectly involved in the nitrogen cycle, exhibiting similar behaviour patterns, and potentially having significant linear correlation, factor analysis was conducted. It included 13 surface water quality parameters (of the Sava and Velika Morava rivers). Considered physico-chemical parameters include: O₂, pH, electrochemical conductivity (κ), NH₄⁺, NO₂⁻, NO₃⁻, organic nitrogen (ON), total nitrogen (TN), Cl⁻, SO₄²⁻, Ferrous, Manganese, and total organic carbon (TOC) (data on B concentration are not available for river water). The Kaiser-Meyer-Olkin test values above 0.6 and the significance of Bartlett's test of sphericity ($p < 0.01$) indicated that the applied factor analysis could be meaningful for processing the given datasets. Sample adequacy measure, represented by the average correlation value between observed parameters, in the principal component analysis applied in this study, exceeded 0.5. By evaluating factor loadings, primary components with the greatest influence were obtained. Oblique factor rotation was applied to clarify each factor and examine partial relationships alongside simple ones, reduce dimensionality, and identify the most suitable model with the fewest factors. The criterion of the eigenvalue was used to define the number of principal components (factors).

Results and Discussion

The quality of the river Sava based on selected parameters

Values of descriptive statistical data processing are shown in Table 1. The mean concentration value of nitrate nitrogen along the Sava River in Serbia is 0.62 mgN/l, and for ammonium ions, it is 0.08 mgN/l.

Table 1. Statistics of selected parameters for the river Sava for the period 2010-2014.

	O ₂	pH	κ	NH ₄ ⁺	NO ₂ ⁻	NO ₃ ⁻	ON	TN	Cl ⁻	SO ₄ ²⁻	Fe _{rast}	Mn _{rast}	TOC	
Unit	mg/l	/	μ/cm	mgN/l	mgN/l	mgN/l	mgN/l	mgN/l	mg/l	mg/l	mg/l	mg/l	mg/l	
No of samples	104	104	104	104	104	102	102	102	102	102	75	76	98	
Average	9.03	8.65	411.54	0.08	0.02	0.62	0.79	1.30	16.57	20.30	0.07	0.01	4.12	
Median	8.93	8.00	403.00	0.08	0.01	0.60	0.46	1.29	15.25	19.00	0.04	0.01	3.70	
Std. Dev.	1.88	7.00	55.89	0.05	0.01	0.27	2.07	0.42	8.24	6.37	0.08	0.02	1.67	
Min	0.98	0.90	269.00	0.00	0.01	0.05	0.05	0.50	1.00	3.00	0.01	0.01	1.70	
Max	13.80	79.00	550.00	0.30	0.06	1.17	21.00	2.60	44.00	37.00	0.45	0.09	10.30	
Percentiles	25	7.81	7.96	378.25	0.04	0.01	0.40	0.23	1.00	10.30	16.00	0.01	0.01	2.70
	50	8.94	8.00	403.00	0.08	0.01	0.60	0.47	1.29	15.25	19.00	0.04	0.01	3.70
	75	10.10	8.10	440.75	0.10	0.02	0.89	0.85	1.50	21.00	25.00	0.10	0.01	5.35

Principal component analysis for the Sava River, according to the criterion of the eigenvalue, revealed 5 extracted factors (PC1-PC5), explaining 66.31% of the total variance of parameters (Table 3). The highest percentage of variance, 20.76%, is explained by the linear correlation between chloride, sulfate, and electrical conductivity, represented by the first extracted factor PC1. Since oxic conditions prevail in the river, these anions move similarly to non-reactive tracers, where their simultaneous increase in concentration with increasing conductivity is the most likely indicator of anthropogenic influence. PC2, explaining 13.51% of the variance, shows a strong correlation between nitrite, total, and ammonium nitrogen concentrations. The identified correlation indicates that the origin of total or ammonium and nitrite nitrogen in the

Sava is common, likely organic, potentially indicating the influence of sewage water, where the dominant form of nitrogen is ammonium ion, and the correlation with nitrites within the same factor may indicate the occurrence of nitrification processes. PC3 explains 12.32% of the total variance and shows a correlation between dissolved iron and manganese in the river. These metal ions are generally not present in significant concentrations under oxic conditions prevailing in the river and therefore exhibit the same behaviour pattern and are extracted into the same factor. PC4 explains 11.58% of the total variance and shows an inverse linear correlation between oxygen and organic carbon. This linear relationship may indicate that oxygen-rich water entering the river (large water volumes, high water levels) corresponds to the dilution of total organic carbon concentrations and oxygen consumption, as the most favorable electron acceptor, for the oxidation of organic carbon. PC5 explains the smallest percentage of variance, 8.14%, and indicates that nitrates (present in low concentrations) in the Sava exhibit a distinct behavioural pattern. Nitrates are not linearly correlated within the second factor, PC2, where predominantly nitrogen compounds are present, likely for three reasons: 1) untreated sewage water carries ammonium as the dominant ion, whose oxidation begins in oxic conditions prevailing in the river, generating nitrites, and then nitrates; 2) besides nitrates from nitrification, nitrates as such come within sewage water (besides ammonium ions); 3) there are other sources of nitrates (leaching from agricultural surfaces, atmospheric deposition).

The quality of the river Velika Morava based on selected parameters

The mean concentration of nitrate nitrogen is 0.90 mgN/l, with 75% of the samples having concentration values up to 1.20 mgN/l. The mean concentration of ammonium ions is 0.19 mgN/l, with 75% of the samples having concentrations up to 0.26 mgN/l (Table 2). The applied principal component analysis for the Velika Morava River revealed 4 distinct factors (PC1-PC4), which account for 48.44% of the total variance of parameters (Table 3). PC1, explaining 18.22% of the variance, shows a correlation between the concentration of ammonium ions, chloride, sulphate, and the electrical conductivity of water. The first identified factor confirms that the highest load of the Velika Morava watershed is noticeable based on the identified correlation, explaining the largest percentage of parameter variance. In the Velika Morava, ammonium cation correlates with other indicators of untreated wastewater discharge. PC2 explains 11.62% of the total variance and demonstrates an inverse linear correlation between the concentration of nitrates and organic nitrogen. Although the concentrations of observed parameters are not high, the correlations revealed between them indicate detectable sources, i.e., the influence of untreated sewage. Factor PC2 is consistent with the explanation of the first factor and indicates the oxidation process of organic nitrogen (nitrification) and the generation of nitrates (reducing the concentration of organic nitrogen). PC3 explains 10.17% of the variance and shows that pH values in the Velika Morava behave according to a separate and independent pattern compared to the mentioned parameters. The fourth factor, PC4, explains 8.44% of the total variance and shows a connection between the concentration of nitrite ions and organic carbon, where their simultaneous decrease in concentration is recorded, indicating their common origin (organic matter and nitrogen components).

Table 2. Statistics of selected parameters for the Velika Morava for the period 2010-2014.

	O ₂	pH	κ	NH ₄ ⁺	NO ₂ ⁻	NO ₃ ⁻	ON	TN	Cl ⁻	SO ₄ ²⁻	Fe ²⁺	Mn ²⁺	TOC	
Unit	mg/l	/	μ/cm	mgN/l	mgN/l	mgN/l	mgN/l	mgN/l	mg/l	mg/l	mg/l	mg/l	mg/l	
No of samples	221	213	221	220	221	221	211	211	219	221	162	160	204	
Average	9.91	8.13	420.63	0.19	0.07	0.90	1.13	4.81	13.25	35.21	0.35	0.40	5.58	
Median	9.90	8.10	428.00	0.13	0.04	0.80	1.08	2.20	13.00	34.00	0.06	0.01	5.05	
Std. Dev.	1.92	0.27	78.99	0.19	0.10	0.56	0.70	25.59	4.29	11.52	1.92	4.44	2.71	
Min	3.70	7.00	27.00	0.01	<0.005	0.08	0.01	0.80	3.30	3.00	0.01	0.01	1.70	
Max	17.40	9.00	770.00	1.00	0.70	3.60	5.25	274.00	26.00	96.00	17.00	56.10	22.20	
Percentile s	25	8.51	7.91	378.50	0.07	0.02	0.50	0.60	1.86	10.40	29.00	0.02	0.01	3.80
	50	9.90	8.10	428.00	0.14	0.04	0.80	1.08	2.20	13.00	34.00	0.06	0.01	5.05
	75	11.10	8.34	463.00	0.26	0.07	1.20	1.60	2.62	16.00	40.00	0.13	0.03	6.40

Table 3 Matrix of selected parameters for the Sava, Danube, and Velika Morava rivers.

Sava					Velika Morava				
Extracted Factors									
	PC1	PC2	PC3	PC4	PC5	PC1	PC2	PC3	PC4
O ₂				0.898					
pH								0.854	
κ	0.838					0.729			
NH ₄ ⁺		0.577				0.581			
NO ₂ ⁻		0.860							-0.689
NO ₃ ⁻					0.923		0.852		
ON							-0.697		
TN		0.731							
Cl	0.876					0.535			
SO ₄ ²⁻	0.775					0.717			
Fe _{rast}			0.620						
Mn _{rast}			0.845						
TOC				-0.529					-0.817

Conclusion

The average concentration of ammonium ion is higher in the Velika Morava River (0.19 mgN/l), the in Sava River (0.08 mgN/l). The average concentration of nitrate nitrogen in the Morava (0.90 mgN/l) is higher than in the Sava (0.62 mgN/l). The highest nitrogen compound load is observed in the Morava River basin. A common pattern observed in both rivers, according to the applied factor analysis, is the same pattern of changes in concentrations and linear dependence of chloride, sulfate, and consequently electrical conductivity. In the Velika Morava, which has the highest population load in the basin, along with chloride and sulfate, a simultaneous increase in the concentration of ammonium ions is evident. The observed inverse linear correlation between the concentration of organic nitrogen and nitrates in the Velika Morava indicates that nitrates in the river are predominantly derived from the oxidation of organic nitrogen. Although the Sava River is characterized by the lower concentrations of ammonium ions and nitrates, a strong correlation has been established between the concentrations of total nitrogen, ammonium ions, and nitrites. Due to the treatment of only approximately 10% of wastewater and the lack of precise data on the types and quantities of fertilizers used, examined surface water quality and nitrogen compound concentrations in Serbia appear to be satisfactory. Nevertheless, analysis using Pearson coefficients reveals a clear correlation between untreated water inflow and subsequent nitrification of organic nitrogen and ammonium ions.

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