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[Poster]

Discharge Trend Dynamics of the Nišava River (Serbia)

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Abstract: This study analyses long-term discharge trends of the Nišava River at the Dimitrovgrad and Niš hydrological stations for the period 1954–2025. Mean annual, seasonal and monthly discharge series were examined using the Mann-Kendall test and Sen's slope estimator, while the Pettitt test was applied to identify abrupt changes in mean annual discharge. Statistically significant decreasing trends in mean annual discharge were detected at both stations, with a stronger absolute decline at Niš. A common change point was identified between 1981 and 1982, after which mean discharge values were lower, while no significant trends were found within the two subperiods. Seasonal and monthly analyses showed that the most pronounced decreases were concentrated in spring and early summer, particularly at Niš.

Keywords: Nišava River, river discharge, discharge trends

Introduction

Climate change affects the hydrological cycle through changes in temperature, precipitation patterns and evapotranspiration, which can consequently alter river discharge regimes and water availability (Langović, 2019). Previous studies in Serbia have predominantly identified decreasing discharge trends. Kovačević-Majkić and Urošev (2014), analysing 94 hydrological stations during 1961–2010, found

decreasing annual trends at 68% of stations, with the largest number of statistically significant decreases occurring in the South Morava River basin. On the Nišava River, a statistically significant decreasing trend was identified at the Niš profile, while the decrease at the Dimitrovgrad profile was not statistically significant. Langović (2019), analysing 20 stations in the South Morava River basin for the period 1968–2017, similarly found decreasing mean annual discharge trends at 85% of stations, with decreasing trends observed at both Dimitrovgrad and Niš, although neither was statistically significant. The aim of this study is to analyse long-term discharge trends of the Nišava River at the Dimitrovgrad and Niš hydrological stations during the period 1954–2025. Mean annual, seasonal and monthly discharge trends are analysed in order to determine their direction, magnitude and statistical significance. The extended observation period, which includes the most recent data up to 2025, enables an updated assessment of discharge dynamics and comparison with previously identified trends.

Methods and data

Discharge data for the hydrological stations Dimitrovgrad and Niš on the Nišava River were obtained from the Hydrological Yearbooks of the Republic Hydrometeorological Service of Serbia (RHMSS) for 1954–2025 (RHMSS, 1954–2025). Monthly and mean annual discharge (Q) series were analysed. Seasonal mean discharge values were calculated for winter (DJF), spring (MAM), summer (JJA) and autumn (SON). For winter, seasonal mean discharge was calculated using December of the reference year and January and February of the following year.

Temporal trends were assessed using the non-parametric Mann-Kendall test (Kendall, 1975), while the magnitude of change was quantified using Sen's slope estimator and expressed in $\text{m}^3/\text{s}/\text{year}$ (Ali et al., 2019). Statistical significance was evaluated at the 0.05 level.

The Pettitt test (Pettitt, 1979) was applied to the mean annual discharge series in order to identify potential abrupt changes. The detected change point was then used to divide the series into two subperiods, 1954–1981 and 1982–2025, for which Mann-Kendall and Sen's slope analyses were repeated.

Results and discussion

The analysis of mean annual discharge for the period 1954–2025 revealed statistically significant decreasing trends at both hydrological stations. At the Dimitrovgrad station, the Mann-Kendall test indicated a significant negative trend ($p=0.0113$), with a Sen's slope of $-0.0133 \text{ m}^3/\text{s}/\text{year}$. A considerably stronger negative trend was identified at the Niš station ($p=0.00024$), where the Sen's slope amounted to $-0.2179 \text{ m}^3/\text{s}/\text{year}$.

The Pettitt test identified the same statistically significant change point at both hydrological stations, occurring between 1981 and 1982. Mean annual discharge decreased from $2.28 \text{ m}^3/\text{s}$ to $1.75 \text{ m}^3/\text{s}$ at the Dimitrovgrad profile and from $34.80 \text{ m}^3/\text{s}$ to $24.45 \text{ m}^3/\text{s}$ at the Niš profile between the 1954–1981 and 1982–2025 subperiods. However, no statistically significant Mann-Kendall trends were detected within either subperiod, suggesting that the long-term decrease is primarily associated with a shift in discharge levels around the beginning of the 1980s rather than a continuous decline throughout the observation period.

Seasonal trend analysis showed predominantly decreasing discharge tendencies at both profiles during the observed period. At the Dimitrovgrad profile, a statistically significant negative trend was identified only in spring ($p=0.0412$), with a Sen's slope of $-0.0213 \text{ m}^3/\text{s}/\text{year}$. At the Niš profile, the spring decrease was also observed, albeit at a higher level of statistical significance ($p=0.0026$), with a Sen's slope of $-0.4297 \text{ m}^3/\text{s}/\text{year}$. A statistically significant decreasing trend was additionally identified in summer ($p=0.0366$; Sen's slope = $-0.1008 \text{ m}^3/\text{s}/\text{year}$), while the remaining seasonal trends were not statistically significant. Results of the Mann-Kendall test and Sen's

slope estimator for mean annual and seasonal discharge are presented in Table 1.

Table 1. Mann-Kendall test and Sen's slope results for mean annual and seasonal discharge

Series	Period	Dimitrovgrad		Niš	
		p-value	Sen's slope (m ³ /s/year)	p-value	Sen's slope (m ³ /s/year)
Annual	1954–2025	0.0113	-0.0133	0.00024	-0.2179
	1954–1981	0.9056	-0.0051	0.2859	-0.1717
	1982–2025	0.8476	0.0017	0.6273	0.0592
Winter	1954–2025	0.1818	-0.0094	0.0934	-0.1632
Spring	1954–2025	0.0412	-0.0213	0.0026	-0.4297
Summer	1954–2025	0.1119	-0.0063	0.0366	-0.1008
Autumn	1954–2025	0.1210	-0.0041	0.5962	-0.0192

Note: Bold p-values indicate statistically significant trends ($p < 0.05$)

Monthly trend analysis identified statistically significant negative trends in May, July and September at the Dimitrovgrad profile, and from March to July at the Niš profile. The largest monthly decrease was observed in May at both profiles, particularly at Niš, where the Sen's slope amounted to $-0.4753 \text{ m}^3/\text{s}/\text{year}$ ($p=0.00005$). Detailed results of the Mann-Kendall test and Sen's slope estimator for individual months are presented in Table 2. Overall, the monthly analysis indicates that the most pronounced decreases are concentrated mainly in spring and early summer, particularly at the downstream Niš profile.

The obtained results are generally consistent with previous research on the Nišava River. Đokić (2015), analysing the period 1961–2009, identified a change point in mean annual discharge at the Niš profile in 1981, with average discharge decreasing from $33.90 \text{ m}^3/\text{s}$ to $23.58 \text{ m}^3/\text{s}$. The present analysis, extended to 2025, identified practically the same change point and comparable mean discharge values. Monthly results also largely confirmed previously identified decreases in spring and early summer, with April additionally showing a significant decrease in the present analysis.

Table 2. Mann-Kendall test and Sen's slope results for monthly discharge during 1954–2025

Month	Dimitrovgrad		Niš	
	p-value	Sen's slope (m ³ /s/year)	p-value	Sen's slope (m ³ /s/year)
January	0.2205	-0.0062	0.2355	-0.0948
February	0.0536	-0.0153	0.1395	-0.1656
March	0.0907	-0.0200	0.0375	-0.3372
April	0.3506	-0.0139	0.0349	-0.3631
May	0.0089	-0.0222	0.00005	-0.4753
June	0.0542	-0.0125	0.0191	-0.1909
July	0.0324	-0.0063	0.0436	-0.0979
August	0.0759	-0.0039	0.2317	-0.0332
September	0.0061	-0.0055	0.0768	-0.0393
October	0.1054	-0.0035	0.8382	-0.0070
November	0.0626	-0.0061	0.2079	-0.0587
December	0.3096	-0.0052	0.1719	-0.1000

Note: Bold p-values indicate statistically significant trends ($p < 0.05$)

The observed changes likely reflect both natural and anthropogenic influences. Langović (2019) reported a correlation of about 0.65 between annual precipitation and discharge at Niš, while Đokić (2015) also identified increasing temperatures and decreasing precipitation in the basin. Anthropogenic impacts are relatively limited near Dimitrovgrad but become more pronounced downstream, where water use for the Niš water-supply system was estimated to reduce discharge at the Niš profile by about 11% on average, with a greater relative impact during low-flow periods. Therefore, the common change point identified at both stations may indicate a broader basin-scale hydrological shift, while water use may additionally affect discharge at the Niš profile.

Conclusions

The analysis of discharge trends on the Nišava River during 1954–2025 revealed statistically significant long-term decreases in mean annual discharge at both Dimitrovgrad and Niš. The common change point identified around 1981/1982 indicates that the long-term

reduction is largely associated with a shift in discharge levels rather than a continuous decline throughout the entire observation period. Seasonal and monthly analyses showed that the most pronounced decreases are concentrated in spring and early summer, particularly at the Niš station. The results are generally consistent with previous studies of the Nišava River and confirm the persistence of previously identified hydrological changes. Natural factors, including changes in temperature and precipitation, together with anthropogenic water use, may contribute to the observed discharge dynamics, especially in the downstream part of the basin.

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