Event-based analysis of nitrate flushing from forested catchment using high-frequency in-stream monitoring data

Klaudija Sapač [(1)], Andrej Vidmar [(1)], Simon Rusjan [(1)]

University of Ljubljana
Faculty of Civil and Geodetic Engineering

(1) University of Ljubljana, Faculty of Civil and Geodetic Engineering, Jamova 2, Ljubljana, Slovenia

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United Nations Educational, Scientific and Cultural Organization · Intergovernmental Hydrological Programme

United Nations Educational, Scientific and Cultural Organization · UNESCO Chair on Water-related Disaster Risk Reduction University of Ljubljana, Ljubljana, Slovenia

INTRODUCTION

This poster presents an analysis of relationships between hydro-meteorological and biogeochemical processes from the perspective of the time of ocurrence of the centroids of discharge, NO_3-N load, and volumetric soil moisture diagrams. Analysis is made on event basis. Data are obtained from our own measurements on a small, forested experimental river catchment in Slovenia.

STUDY AREA

River	Kuzlovec
Drainage area	0.7 km^2
Stream length	1.3 km
Catchment slope	mean: 52%; max: 105%
Stream slope	22%
Annual precipitation	1600-1800 mm
Geology	mainly limestone and dolomite

DATA

Time period	July 2019-January 2020
Number of events	29
Variables	Rainfall: amount, duration, intensity; NO_3-N load, soil moisture in three depths, discharge
Time step	20 minutes

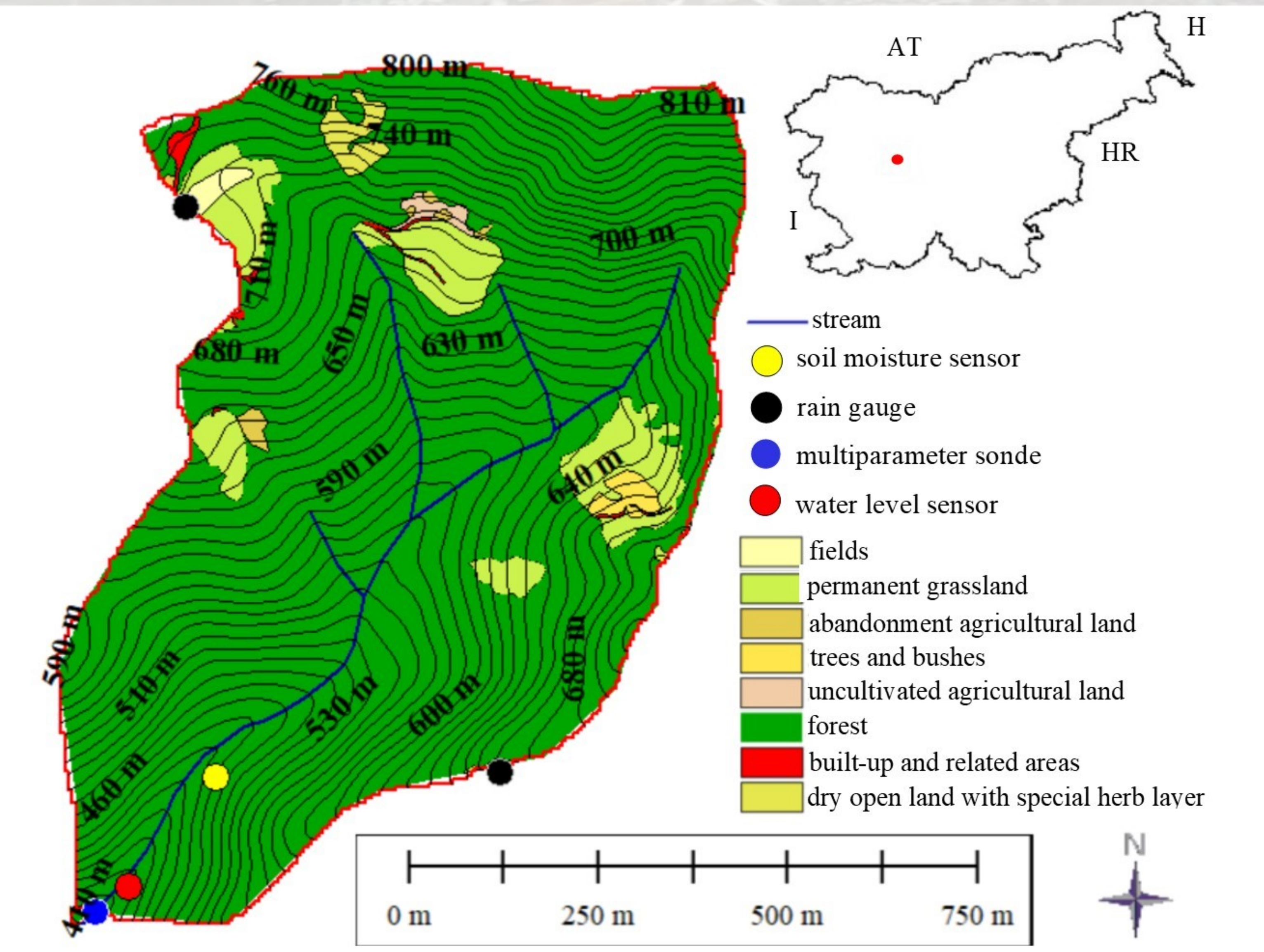

Figure 1: Kuzlovec experimental catchment with locations of measurement equipment.

METHODOLOGY

Lag times are evaluated as time from the precipitation hyetograph centroid to the time of centroid of discharge (LAG_Q), soil moisture (LAG_{SM}) and NO_3-N (LAG_N) flux diagrams. Individual times of centroids (M_x) are calculated as:

$$M_X = \frac{\sum_{i=1}^{n}(Y_i * t_i)}{\sum_{i=1}^{n} Y_i}$$

Y_i … amount of rainfall

t_i … time from the beginning of the event

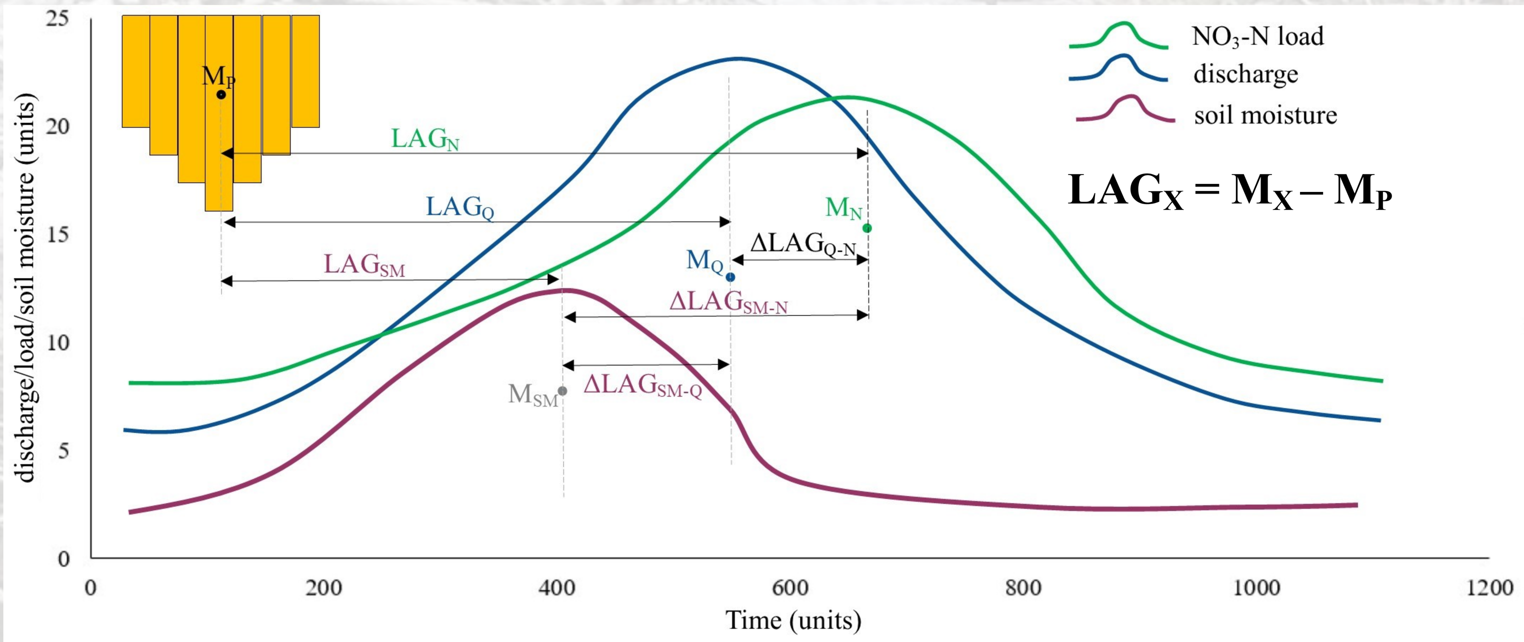

Figure 2: Schematic representation of lag times.

Linear regression was used to analyse relationship between individual lag times.

Multiple linear regression model was performed to model the relationship between dependent variables and the independent variable.

Independent variable: LAG_N; LAG_Q

Dependent variables: duration and amount of rainfall ($P_{duration}$, P_{amount}), mean and maximum rainfall intensity (I_{mean}, I_{max}), difference between max and min NO_3-N concentration and discharge (ΔC, ΔQ), maximum concentration and discharge (C_{max}, Q_{max}), difference between max and min soil water content at 15, 40, and 70 cm depths ($\Delta SM15$, $\Delta SM40$, $\Delta SM70$).

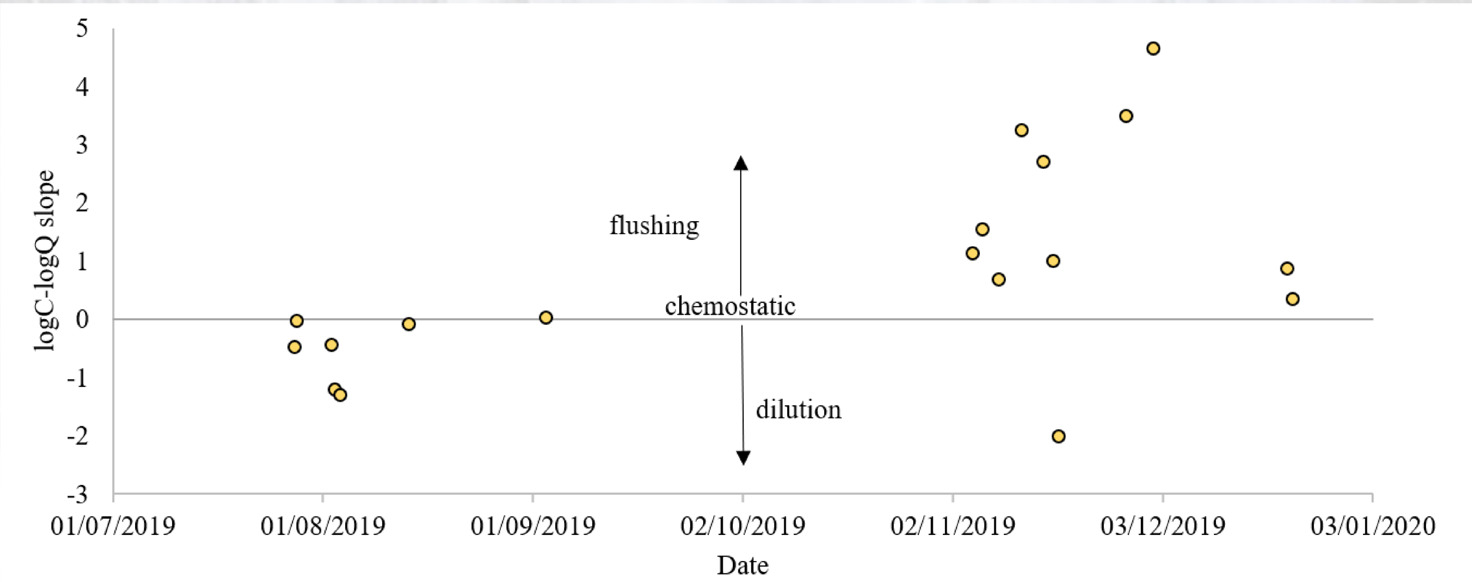

Figure 3: Events show seasonality of export regimes.

RESULTS

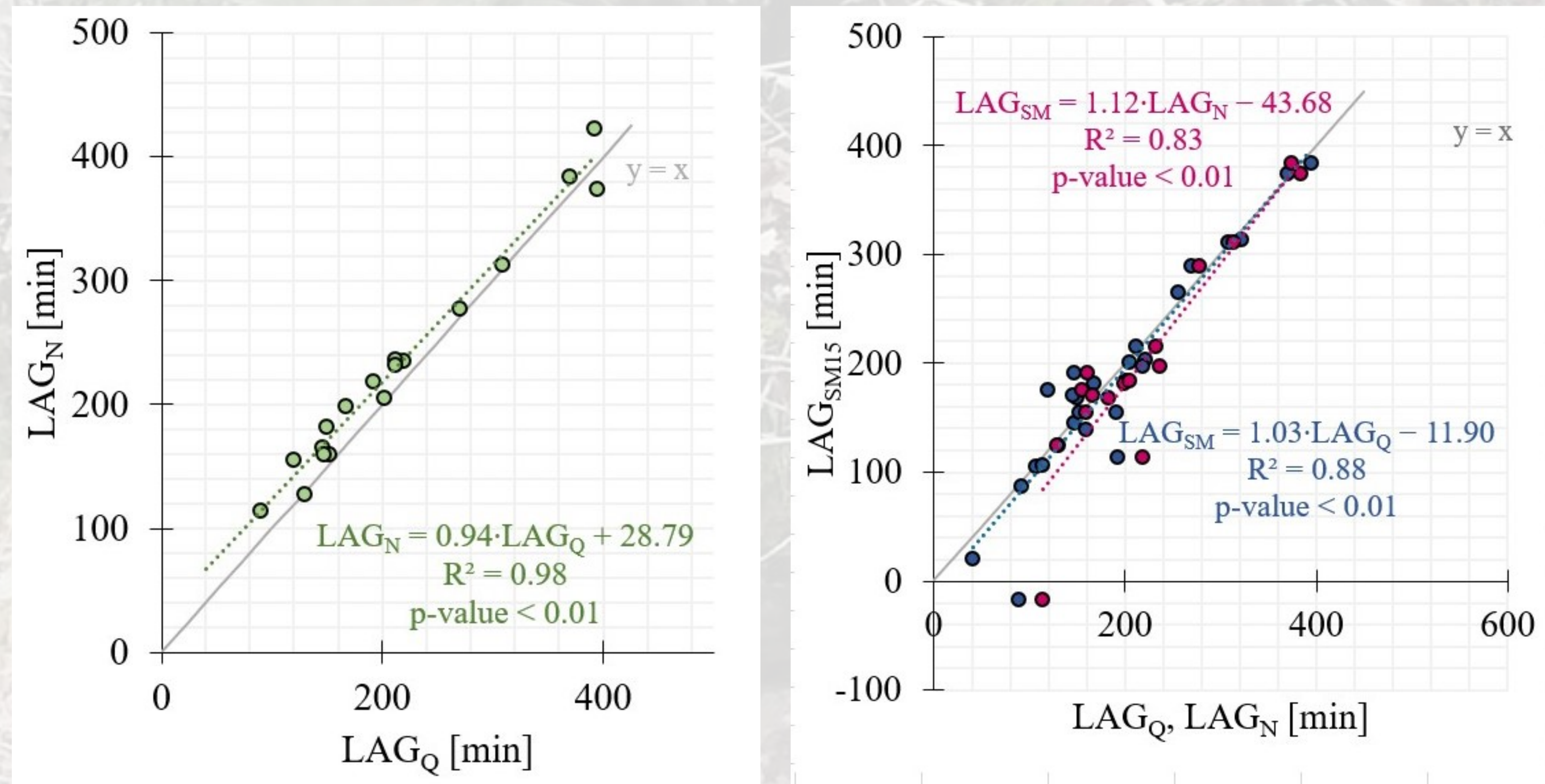

Figure 4: Linear regression between LAG_N and LAG_Q (left) and linear regression between LAG_{SM15} and LAG_Q and LAG_N.

Table 1: Coefficients of MLR for LAG_Q and LAG_N. Models explain more than 90% of variance and are statistically significant with adjusted R^2 0.76 and 0.77.

LAG_N						LAG_Q					
Variable	Estimate	Std. Error	t value	Pr(>|t|)	Sign.	Variable	Estimate	Std. Error	t value	Pr(>|t|)	Sign.
Intercept	210.30	99.27	2.12	0.08	*	Intercept	252.10	108.30	2.33	0.06	*
$P_{duration}$	-0.09	0.08	-1.13	0.30		$P_{duration}$	-0.10	0.09	-1.07	0.33	
P_{amount}	10.98	3.34	3.29	0.02	**	P_{amount}	11.62	3.64	3.19	0.02	**
I_{mean}	-582.00	438.50	-1.33	0.23		I_{mean}	-746.90	478.50	-1.56	0.17	
I_{max}	29.13	212.80	0.14	0.90		I_{max}	139.50	232.20	0.60	0.57	
ΔC	108.60	121.00	0.90	0.40		ΔC	136.30	132.10	1.03	0.34	
C_{max}	-106.70	83.28	-1.28	0.25		C_{max}	-130.80	90.88	-1.44	0.20	
ΔQ	-23.49	15.09	-1.56	0.17		ΔQ	-24.72	16.46	-1.50	0.18	
Q_{max}	18.02	16.12	1.12	0.31		Q_{max}	17.57	17.59	1.00	0.36	
ΔSM15	13180.00	5190.00	2.54	0.04	**	ΔSM15	10910.00	5664.00	1.93	0.10	
ΔSM40	-6649.00	2748.00	-2.42	0.05	*	ΔSM40	-6994.00	2999.00	-2.33	0.06	*
ΔSM70	-3024.00	1730.00	-1.75	0.13		ΔSM70	-3591.00	1888.00	-1.90	0.11	

** p-value < 0.05, * p-value < 0.1

CONCLUSIONS

Analysis showed that **lag times can indicate mechanisms for controlling the NO_3-N flux formation** in relation to runoff, regardless of event properties and season.

Amount of rainfall is most descriptive variable for LAG_Q and LAG_N, while for LAG_N also change in soil moisture is also significant indicating forest soil as source of NO_3-N load. Rainfall amount and runoff formation through soil are the main controlling mechanisms.

FURTHER READING

Sapač et al. Lag Times as Indicators of Hydrological Mechanisms Responsible for NO_3-N Flushing in a Forested Headwater Catchment. Water 2020, 12, 1092. https://doi.org/10.3390/w12041092

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