Nutrient export dynamics at catchment scale – a Germany-wide analysis of dominant controls

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Motivation

Nutrient inputs from human activities have increased the pressure on aquatic ecosystems. Spatio-temporal variability of solute concentrations in streams determine water quality and are closely linked to ecosystem health. Catchments are complex units, which integrate multiple processes driving hydrological and solute dynamics. Understanding drivers of that integration can improve the assessment of strategies to manage stream water quality. Here, we analyse nutrient export dynamics of catchments using a data-driven top-down-approach.

Objectives:

- Classify German catchments according to their nutrient export dynamics
- Identify patterns, drivers and processes at catchment scale

Methods

- 1386 nested catchments covering an area of about 80% of Germany
- Nutrient concentrations (NO_3^-, PO_4^{3-}) from regular national monitoring on a biweekly to bimonthly basis
- 441 related discharge stations exist
- Samples since 2000 used to analyse current patterns

Export metrics:

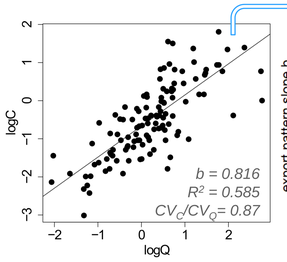
- slope b from power-law concentration-discharge (C-Q) relations
- ratio of variation coefficients CV_C/CV_Q

Catchment characteristics:

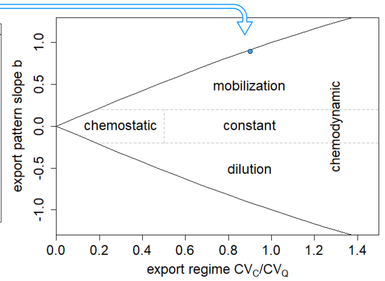
- topography, hydrology, geology and land use

Linked by partial least squares regression (PLSR)

$$C = aQ^b$$

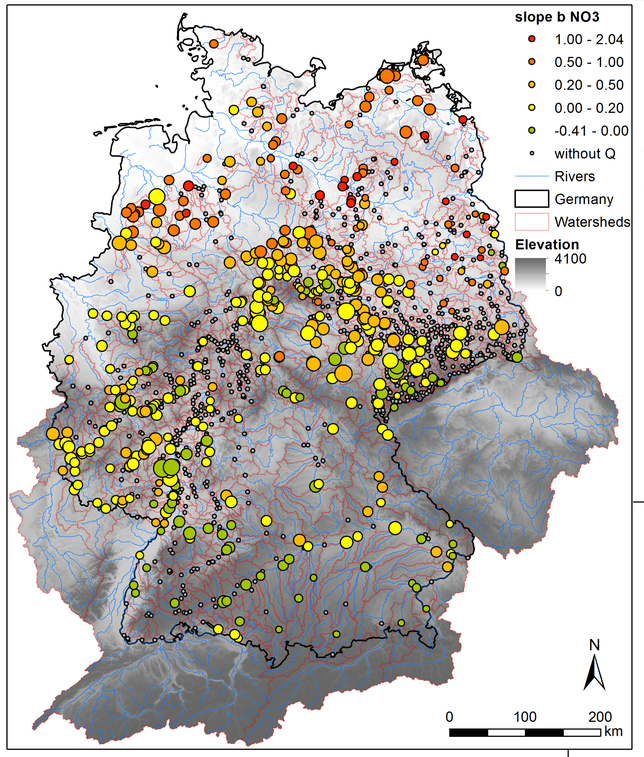


Concentration-discharge (C-Q) relation for one station

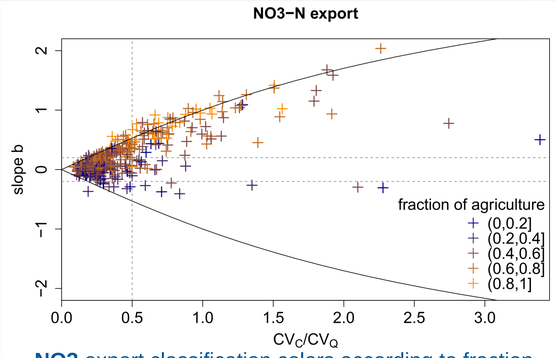


Export classification scheme

Results

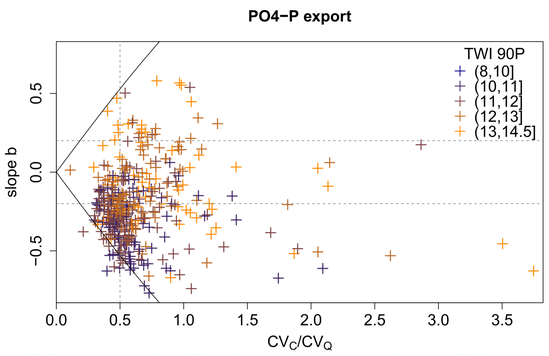


NO3 slope b of C-Q-relations with size according to mean NO3 concentration

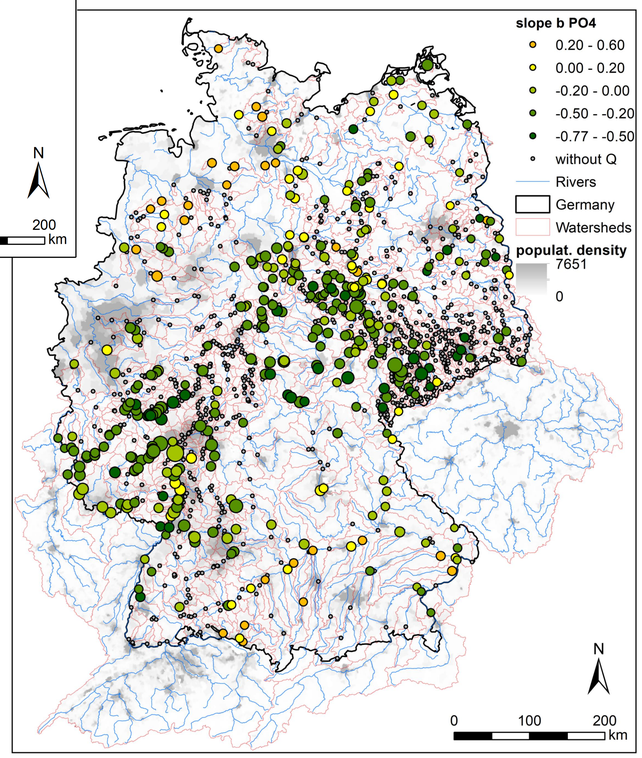


NO3 export classification colors according to fraction of agriculture

- Many agricultural catchments show accretion patterns for NO3

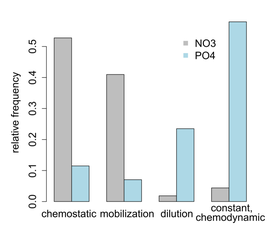


PO4 export classification colors according to 90th percentile of topographic wetness index (TWI)

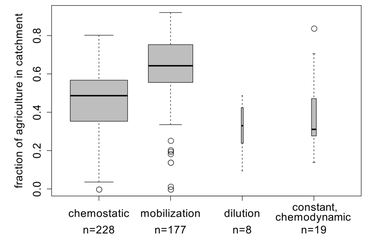


PO4 slope b of C-Q-relations with size according to mean PO4

- NO3: chemostasis and mobilization C-Q pattern prevail
- PO4: chemodynamic with dilution and constant pattern



Export classes per solute



Agriculture fraction in NO3 classes

Controlling catchment characteristics (PLSR):

	Metric	R^2	Significant predictors (direction of influence)
NO3	mean	0.58	forest (-), agriculture (+), sediment(-), CV_Q (+), specific Q (-)
	b	0.63	TWI (+), elevation & slope (-), sediment (+), drainage density (-), agriculture (+), forest (-)
	CV_C/CV_Q	0.58	sediment (+), TWI (+), BFI (+), CV_Q (-), drainage density (-)
PO4	mean	0.46	sediment (-), population density (+), P from WTP (+), artificial surfaces (+)
	b	0.56	N surplus (+), sediment (+), TWI_{90P} (+), median TWI (-), Q season. (+)
	CV_C/CV_Q	0.30	Q flashiness (+), CV_Q (-), BFI (+), sediment (+), Q seasonality (+)

Outlook

- Expand dataset with modelled Q to increase number of catchments with C-Q relations
- Extend catchment characteristics
- Classification of nutrient limitations and their temporal shifts

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References: Musolff, A., et al. (2015). "Catchment controls on solute export." Advances in Water Resources 86: 133-146.