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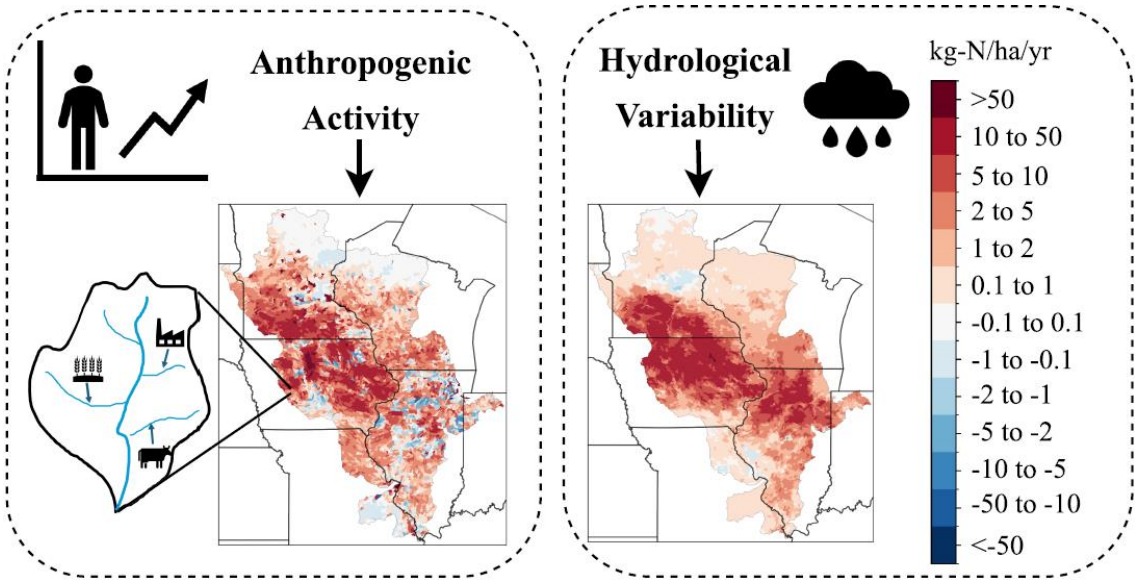
How do Hydrological Variability and Human Activities Control the Spatiotemporal Changes of Riverine Nitrogen Export in the Upper Mississippi River Basin?

Background/Objective

Excessive nitrogen (N) export from agricultural watersheds in the Upper Mississippi River Basin (UMRB) results in water quality challenges and contributes to eutrophication and hypoxia in the Gulf. This work explores spatiotemporal river nitrate/nitrite (NO_3^- + NO_2^-) export dynamics across the UMRB and quantifies the distinct impacts of anthropogenic activity and hydrologic variability.

Approach

The WRTDS-K model was used to estimate annual NO_3^- + NO_2^--N loads from 2001-2020 at monitoring stations in the UMRB. These estimates were used to calibrate the SPARROW model and estimate the spatiotemporal NO_3^- + NO_2^--N export patterns for the 2001-2005 and 2016-2020 periods. Scenario analysis was used to differentiate anthropogenic and hydrologic drivers over these time periods.



Riverine NO_3^- + NO_2^--N export change from 2001-2005 to 2016-2020.

Results

NO_3^- + NO_2^--N yield increased by 9.7 kg/ha/yr on average between 2001-2005 and 2016-2020, of which, anthropogenic activities contributed 4.8 kg/ha/yr and hydrological variability contributed 4.9 kg/ha/yr. Northern and western UMRB had combined anthropogenic and hydrologic influences while the east-central regions had primarily hydrologically driven changes. Agricultural sources including fertilizer, manure, and biological N fixation collectively contributed over 80% of NO_3^- + NO_2^--N loading throughout the basin.

Significance/Impacts

This framework for distinguishing human and hydrological impacts on riverine N export provides critical insight for developing effective watershed management strategies for reducing nutrient loss and improving water quality.

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