Inferring drivers of nitrate and sediment event dynamics from hysteresis metrics for two large agricultural watersheds

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Abstract

Excess nitrate and sediment, mobilized by precipitation events and transported into surface waters, is a global water quality challenge. Recent advances in high frequency, in-situ water quality monitoring sensors have created opportunities to investigate constituent concentration dynamics during short-term hydrological changes. In this study, we characterized the event-scale variability of nitrate (NO 3 -) and turbidity (a surrogate for sediment transport) in two large agricultural watersheds of the Upper Mississippi River Basin using hysteresis loop characteristics to determine sources and dominant transport mechanisms. We then applied factor analysis to detect variable groupings and thus determine controls on nitrate and sediment dynamics. We found that NO 3 - hysteresis behavior was consistent between the two watersheds and demonstrated distal contributions and/or late-event mobilization and flushing that was controlled by the characteristics of the event hydrology (such as, event duration and magnitude of event discharge). In contrast, turbidity hysteresis loops indicated sediment delivery differed between the two watersheds; the smaller watershed with more diverse land use demonstrated consistent early-event flushing or rapidly responding pathways whereas the larger, more agricultural watershed showed variability between dilution vs. flushing as well as delivery pathways between events. This dynamic behavior as well as the magnitude of the hysteretic response was principally related to the time lag between turbidity and discharge peaks for the smaller site, and to the event peak discharge and subsequent stream erosive power at the larger site that switched behavior. This result is critical for watershed water quality management especially in the context of a changing climate and further underscores the utility of high-frequency sensors monitoring data to offer deep insights into hydrological processes controls on contaminant transport and delivery.

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