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Modeling the effects of wastewater on nitrogen retention in a human-impacted river under low-flow conditions in the Nanfei River (China)

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Excessive anthropogenic nitrogen (N) added to riverine systems by wastewater is a water quality problem of growing concern. Instream N retention plays an important role in regulating N downstream delivery. In this study we quantified the effects of wastewater discharge on instream N retention capacity and pathway under low-flow conditions in the Nanfei River (China). A spatially-intensive water quality monitoring campaign was conducted to measure relevant water quality parameters and to support the application of the river water quality model WASP7.5 to the 11-km wastewater-impacted river reach. The N retention capacities and pathways of a pristine upstream reach (reach A), a reach impacted by untreated wastewater (reach B) and a reach dominated by effluent discharge (reach C) were quantified using the model results after calibration and validation. The effects of four engineering controls on instream N retention and downstream export were also investigated by scenario analysis. The results showed that the N retention ratios of reaches A, B and C under low flow conditions were 65%, 45% and 35%, respectively. Even though compared with reach A the assimilatory N uptake rates increased in reach B. Reach C became a hotspot for denitrification due to the increased nitrate concentrations and hypoxic conditions, the instream N retention capacities were significantly impaired by the discharges of wastewaters. Besides, the effects of the wastewaters on the N retention pathways (assimilatory uptake vs. denitrification) were regulated by their impacts on river metabolism. Finally, the scenario analysis results of four engineering controls showed that the suggested wastewater treatment plant (WWTP) upgrade was the most effective measure to reduce the downstream export of N by 13-15%.