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Estimating river water-quality trends under different flow conditions

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A number of statistical approaches have been developed to quantify the overall trend in river water quality, but most approaches are not intended for reporting separate trends for different flow conditions. We propose an approach called FN_{2Q}, which is an extension of the flow-normalization (FN) procedure of the well-established WRTDS ("Weighted Regressions on Time, Discharge, and Season") method. The FN_{2Q} approach provides a daily time series of low-flow and high-flow FN flux estimates that represent the lower and upper half of daily riverflow observations that occurred on each calendar day across the period of record. These daily estimates can be summarized into any time period of interest (e.g., monthly, seasonal, or annual) for quantifying trends. The proposed approach is illustrated with an application to a record of total nitrogen concentration (632 samples) collected between 1985 and 2018 from the South Fork Shenandoah River at Front Royal, Virginia (USA). Results show that the overall FN flux of total nitrogen has declined in the period of 1985–2018, which is mainly attributable to FN flux decline in the low-flow class. Furthermore, the decline in the low-flow class was highly correlated with wastewater effluent loads, indicating that the upgrades of treatment technology at wastewater treatment facilities have likely led to water-quality improvement under low-flow conditions. The high-flow FN flux showed a spike around 2007, which was likely caused by increased delivery of particulate nitrogen associated with sediment transport. The case study demonstrates the utility of the FN_{2Q} approach toward not only characterizing the changes in river water quality but also guiding the direction of additional analysis for capturing the underlying drivers. The FN_{2Q} approach (and the published code) can easily be applied to widely available river monitoring records to quantify water-quality trends under different flow conditions to enhance understanding of river water-quality dynamics. (Journal article: https://doi.org/10.1016/j.scitotenv.2020.143562; R code and data release: https://doi.org/10.5066/P9LBJEY1).