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A framework for analysing water quality observations to detect change in the context of natural variability and uncertainty

C. Lloyd (1), J. Freer (1), P. Johnes (2), A. Collins (3), and the Hampshire Avon DTC Team

(1) University of Bristol, School of Geographical Sciences, Bristol, United Kingdom, (2) University of Reading, School of Human & Environmental Sciences, Reading, United Kingdom, (3) ADAS UK, Wolverhampton, United Kingdom.

The European Water Framework Directive (WFD) is a main driver for enhancing water management policies and increasing infrastructure investment to improve all water bodies to good ecological status. This requires scientists, managers and regulators to develop an effective evidence base for understanding which strategies maximise the cost-benefit associated with water quality improvements. Such evidence is underpinned by national monitoring and predictions of change are often quantified through the application of computer models. This paper is associated with understanding how observations of water quality within river systems at different temporal resolutions and types of monitoring strategies enable us to understand and detect changes over and above the natural variability. Therefore we explore the inter- and intra-annual variabilities of water quality data in the form of concentrations and loads to benchmark the expected variability and uncertainty under different sampling regimes.

Recent research has investigated the effects of sampling designs on commonly used metrics for assessing nutrient fluxes, such as the estimation of annual pollutant loads in catchments. However, there have been significantly fewer studies which have considered the effect of sampling frequencies on the detection of inter- and intra-annual variability in water quality time-series and which include the uncertainty estimates in such data. This is important as it determines both the resolution of sampling which is needed for effective monitoring schemes and also the length of dataset which is necessary to characterise baseline and post-remediation behaviours adequately. Without this, we do not have an effective evidence base that enables us to quantify changes in pollutants when improving water quality management plans and associated infrastructure investment.

The study uses a Monte-Carlo based approach to generate deviate sample sets of varying time resolutions from measured continuous time-series of paired discharge and nitrate concentrations. These deviate datasets are used to calculate conventional metrics including annual loads, peak pollutant concentrations and pollution event frequencies. We provide an assessment of the uncertainty associated with these metrics, including the determination of variance and probability distributions. The approach is applied to a number of different datasets of varying length and sampling resolution, including a 40-year weekly resolution dataset from the River Frome, UK and a 4-year daily resolution dataset from the Hampshire Avon, UK. The results will be used to benchmark current water quality status for the Hampshire Avon Demonstration Test Catchment (DTC) project before a range of mitigation experiments are implemented (see http://www.avondtc.org.uk/).