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Scale effect in nutrient transport along a rural river system: the River Eden, Cumbria, northwest, England

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ABSTRACT
Only a limited amount of information derived from studies conducted at small catchment scales can be transferred to large scales because of the non-linear scale effects, thus necessitating studies (including nutrient concentrations and yields) across a range of scales. Here we present results from an investigation of spatial scale pattern and temporal variability of nutrient concentration in the River Eden in northwest England, a nested catchment stretching from Gais Gill (1.1 km2) to Great Corby (1373 km2). The monitoring involved seasonal campaigns and spot sampling of river water quality, using two United Kingdom national catchment study platforms. These are the Catchment Hydrology And Sustainable Management (CHASM) project, that provides a large spatial scale study platform along the Eden, and the Demonstration Test Catchment (DTC) project that provides high resolution data for contrasting land uses that could help to explain, in detail, the mechanisms for transport of nutrients to the river. Nitrate concentration shows a clear increasing trend with the catchment area and there is highly significant difference ($P<0.001$) among the catchments. Compared with the headwater areas, phosphorus (P) and suspended sediment (SS) concentrations are significantly higher ($P<0.05$) downstream but do not show a very clear spatial pattern. An alternative explanation was therefore sought for their distribution along the river. Generally, intensity of agricultural activities appears to influence the concentrations of these water quality parameters. The field data show that the amount of nutrients and suspended sediment is higher in catchments with higher farming activities. This underscores the importance of the distribution of agricultural land use as a driving force in nutrient transport in River Eden. Agricultural production generally increases downstream and may therefore appear to support a spatial scale dependency in nutrient yield.
Higher nitrate concentration is associated with the period of low flow (strongest inverse relationship, $R2 = 0.97$ was recorded in in autumn sampling campaign near Appleby gauging station). In contrast, phosphorus and suspended sediment are positively associated with discharge (strongest relationship $R2 = 0.94$ for reactive P and $R2 = 0.97$ for total P were both recorded in spring campaign at Temple Sowerby gauging station; $R2 = 0.87$ was recorded in autumn seasonal campaign near Great Corby gauging station). Similarly the dryness or wetness of a season affects the nutrient concentrations.
Thus, it appears that hydrology and land use distribution, from the headwater to the lowland areas downstream, control the spatial behaviour of the nutrient and suspended sediment concentration in the River Eden. The findings was generalized for wider applicability in the UK using the TOPCAT-NP model.
Key Word: Scale, Nitrate, Phosphorus, Sediment, River Eden, agricultural activities, TOPCAT-NP