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Investigating the role of suspended particulate organic matter in aquatic ecosystems: a missing 'hotspot' in the continuum?

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Hydrological flows are a major link between terrestrial and aquatic ecosystems. They store, transport, and process large amounts of organic matter (OM) to rivers, which influences aquatic biota, water quality, fishery productivity, and global biogeochemical cycles. However, the current understanding of its sources, composition and dynamics is still limited. Even though OM is transported downstream in dissolved (DOM) and particulate (POM) forms with multiple interactions between these phases, POM composition is less well understood. Moreover, the impacts of anthropogenic landscape changes, and increasing urban and agricultural pollution on the composition of POM, and therefore its role within the aquatic ecosystems remains poorly understood.

Here, we present a broad molecular scale characterisation of suspended POM at three locations in the River Chew, UK. Discharge in the lower River Chew is strongly influenced by controlled releases from Chew Valley Lake, a drinking water reservoir lying immediately upstream from the study reach. This, together with the input of new POM from tributaries, from bank erosion of floodplain stores, and the flushing of autochthonous POM produced in the reservoir results in changes in nature and composition of POM in the study reach, and changes in channel morphology and the nature of river bed substrate; generating a complex POM composition that reflect contributing sources in the catchment. In order to study this material, suspended POM was collected using time-integrated samplers at (1) downstream from the reservoir and a major tributary (the Chew Stoke Stream), (2) at the effluent discharge point from the Chew Stoke sewage treatment works (STW), and (3) downstream from the STW discharge point. Suspended POM samples were then analysed by conventional gas chromatography (GC), GC mass spectrometry (GC-MS), and GC high-resolution mass spectrometry (GC-HRMS). The characterisation included neutral carbohydrates, hydrolysable amino acids, and lipids biomarkers (e.g. fatty acids, sterols, alcohols). Despite the proximity of the three sampling sites, significant differences in the molecular composition of the POM have been observed, which might infer the different sources and diagenetic state of the suspended material.

We also tested the potential of this suspended POM as a 'hotspot' substrate for the processing of organic and inorganic compounds using an experimental ^{15}N stable isotope probing (SIP) approach. Mesocosm experiments were set up for 3 days using suspended POM from the three sites, sterile river water, and doubly labelled L-glutamic acid (^{15}N, ^{13}C) or $K^{15}NO_3$. Suspended sediment and water samples were collected at 4, 21, 45, and 72 h. Compound-specific ^{15}N values of individual amino acids were then analysed by GC-combustion-isotope ratio MS (GC-C-IRMS). This approach allowed us to demonstrate uptake of N-containing organic and inorganic substrates by living suspended POM via metabolic pathways in which new proteinaceous amino acids are biosynthesized. This will help us to define the role of POM in the riverine ecosystem nutrient cycling and its relationship to DOM.