Understanding climate control and hydrological regulation of dissolved organic carbon concentration in a Mediterranean headwater catchment through long-term, high-frequency monitoring

Alfonso Senatore1, Giuseppina Anna Corrente2, Eugenio Licio Argento1, Massimo Micieli1,3, Giuseppe Mendicino1, Amerigo Beneduci2, and Gianluca Botter3
1Dept. of Environmental Engineering, University of Calabria, Arcavacata di Rende (CS), Italy (alfonso.senatore@unical.it, eugenio.licio.argento@gmail.com, massimo.micieli@unical.it, giuseppe.mendicino@unical.it)
2Dept. of Chemistry, University of Calabria, Arcavacata di Rende (CS), Italy (giuseppina.corrente@unical.it, amerigo.beneduci@unical.it)
3Dept. of Civil, Architectural and Environmental Engineering, University of Padua, Padua, Italy (gianluca.botter@dicea.unipd.it)

Inland waters can be interpreted as “active pipelines” in which the complex dissolved organic carbon (DOC) dynamics occur, eventually contributing to negative net ecosystem production. Hydrological factors highly contribute to the DOC balance at the reach scale. Seasonal and event-based hydrological variability, particularly in headwater streams, affects both stream-hillslope organic matter exchanges and overall fluvial network connectivity, leading to significant space and time changes in sources and processes regulating DOC. Technological advances allow fine and continuous time scale measurements of several physicochemical parameters with optical aquatic sensors, providing great potential for a better understanding of aquatic ecosystems functioning.

This study investigates the spatial and temporal dynamics of DOC concentration in a Mediterranean headwater catchment (Turbolo River catchment, southern Italy) equipped with two multiparameter sondes providing approximately 2.5 years (May 2019 to January 2022) of continuous high-frequency measurements of several chemical-physical variables, among which DOC-related parameters (fluorescent dissolved organic matter - fDOM, streamwater temperature and turbidity) at two different outlets. One sonde was installed in a quasi-pristine sub-catchment, while the other at the catchment outlet, characterized by some anthropogenic disturbances.

The specific features of the upslope sub-catchments were considered to address the connection between seasonal and hydrologic dynamics and DOC changes. Continuous observations were supported by meteo-hydrological observations and discrete monitoring carried out in the period January-April 2021 when 59 samples were collected on-field and analysed in the laboratory to achieve reference DOC values, used for an original correction method of measured fDOM values.

Results concern both the seasonal variability of background values and hydrological regulation of DOC export. Specifically, applying a Principal Component Analysis multivariate approach to the
background values, seasonal clusters emerged with a clear temporal trajectory, highlighting similarities and differences among DOC and other measured parameters. Furthermore, DOC concentrations were positively correlated with discharge and even more with antecedent precipitation, reflecting the flushing effect of intense and prolonged precipitation. In both sites, the accumulated export of DOC for discharge values below the flow equalled or exceeded for 10% of the time (Q10) was lower than 35% of the total. Also, some differences in DOC concentration emerged between the two sites, with increased values with high flows in the catchment more affected by disturbances.

High-frequency monitoring proved to be a valuable tool to explain DOC dynamics at multiple time scales with a quantitative approach, highlighting the climate control and the hydrological regulation on DOC production and export.