The Dynamics of NOM in Natural Waters

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The dissolved component of natural organic matter (DOM) has been increasing in natural waters draining organic soils for the last 30-40 years across large parts of Northern Europe and North America, with wide-ranging implications for terrestrial carbon balances, freshwater aquatic ecosystems and drinking water treatment. Analyses of long-term monitoring data, supported by field manipulation experiments, show that the primary driver of these increasing trends has been recovery from the effects of acidifying sulphur deposition, which has declined dramatically across Europe since the 1970s. The accompanying reductions in soil water acidity and ionic strength have effectively made organic matter more soluble, allowing more of this material to be flushed into drainage networks. There is some evidence that other environmental factors linked to land-use, particularly on peatlands (as the largest source of DOM) may have had 'superimposed' effects on DOM concentrations in some situations, for example due to peatland drainage, managed burning and plantation forestry. On the other hand, evidence from the Blue Lough monitoring catchment in the Mourne Mountains following a wildfire in 2011 suggests that, in some circumstances, fires may actually reduce DOM loss.

The ultimate significance of rising DOM trends for ecosystem carbon and CO_2 balances, as well as their implications for drinking water supplies, depend on the extent to which organic matter leached from peatlands and other organic soils is reactive within the aquatic system. Literature data show that the rate, location and extent of DOM reactivity can be highly variable, with the 'half-life' of this material apparently ranging from days to years between studies. Ongoing research in the Conwy catchment, North Wales (part of the NERC Macronutrients and DOMAINE programmes) suggest that DOM can be mineralised to CO_2 by aquatic biota, but that this process is relatively slow relative to the residence time of water within drainage networks. If DOM is exposed to light, photo-chemical processes can mineralise DOM more rapidly, particularly in the case of the highly-coloured, light-absorbing material produced by peatlands. In nutrient-enriched agricultural drainage waters, on the other hand, it appears that production of 'new' DOM within the aquatic system can occur more rapidly than 'old' terrestrially-derived DOM is consumed, leading both to net increases in overall DOM concentrations, and in a shift from hydrophobic to hydrophilic compounds. This process appears to be accelerated by increased inputs of agricultural nitrogen and phosphorus.

The freshwater processing of DOM becomes proportionally more important where water residence times are extended within lakes and reservoirs. Recent work a number of reservoirs operated by Scottish Water (CREW Catchment management for drinking water project CRW2014/17) indicates that reservoirs receiving water from peaty catchments can act as strong net sinks for DOM, especially where water residence times are high. On the other hand, reservoirs that are affected by nutrient inputs appear to act as net sources of DOM, may also have algal problems, and generate increased levels of hydrophilic compounds also make this water harder to treat.

The suite of processes affecting catchment DOM production (acid deposition, land-use) and aquatic DOM cycling (photo-chemical breakdown, nutrient-driven production) have been incorporated in a model developed by CEH as part of the CREW project. This relatively simple model aims to support decision-making by water supply companies with regard to the most effective management options within supply catchments (e.g. peatland re-wetting, controls on burning, forestry and agricultural nutrients), the extent to which these measures have the potential to offset ongoing long-term increases, and therefore the likely requirements for upgrading of existing water treatment assets.