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Is marine dissolved organic matter the "missing sink" for soil-derived black carbon?

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The thermal alteration of biomass during wildfires can be an important factor for the stabilization of organic matter in soils. Black carbon, i.e. biochars and soot, is more resistant to biodegradation than unaltered biomass, and it can therefore accumulate in soils and sediments. Our knowledge on the turnover of black carbon is still very fragmentary, and the known loss rates do not account for the estimated production rates. Major loss mechanisms remain unidentified or have been underestimated. Recently, we have identified a major thermogenic component in dissolved organic matter (DOM) of the deep ocean. We hypothesize that black carbon in soils is solubilized over time, probably via microbial interaction, and transported via rivers into the ocean. DOM, one of the largest organic carbon pools on earth, could therefore be an important transport medium of soil-derived black carbon. A case study was performed in the Suwannee River estuary and adjacent oceanic shelf (Florida, USA). The Suwannee River drains extensive wetlands and fire-impacted forests. The fate of dissolved black carbon was traced from the river through its estuary into the open Gulf of Mexico. Black carbon was molecularly quantified as benzenepolycarboxylic acids after nitric acid oxidation via a new UPLC method (ultra-performance liquid chromatography). The molecular analysis was accompanied by optical (excitation-emission matrix fluorescence and absorbance spectroscopy) and elemental characterization of DOM. A major component (approx. 10% on a carbon basis) of Suwannee River DOM could be identified as black carbon. The concentration of black carbon decreased offshore, and on the open ocean only about 1% of DOM could be identified as black carbon. In the deep ocean, the thermogenic component of DOM is higher and approx. 2.4% of DOM. The surface ocean must therefore be an efficient sink for dissolved black carbon. We hypothesize that sunlight may initiate photochemical reactions that cause a loss of dissolved black carbon in the surface ocean. To test this hypothesis we performed photodegradation experiments with Suwannee River DOM. First results indicate significant molecular modifications of riverine DOM in support of our hypothesis. We conclude that dissolution, riverine transport of DOM (approx. 0.02 Gt dissolved black carbon per year) and subsequent photochemical reactions at the sea surface may largely account for the missing sink of black carbon in the global carbon cycle.