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Organic matter characterization by infrared spectroscopic methods in lake sediment records from boreal and subarctic Sweden: Implications for long-term carbon cycling

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Freshwater systems play an important role in the global carbon cycle. In this dynamic system, inorganic and organic carbon can be incorporated into biota, effluxed to the atmosphere or accumulated in sediments. The amount and composition of the carbon, derived from both aquatic and terrestrial sources, accumulated in sediments depend on the climatic and environmental conditions present in the lake and its catchment, and are thus sensitive to changes in, e.g., temperature, precipitation, vegetation and hydrological flow patterns.

In this study, we show the application of infrared spectroscopic methods to qualitatively and quantitatively characterize organic matter stored in lake sediments with a focus on changes in the source of terrestrial-derived organic matter. Infrared spectroscopic methods facilitate a fast, cost-efficient and non-destructive analysis of minerogenic as well as organic sediment components. We applied three different infrared spectroscopic analyses – visible-near infrared spectroscopy (VNIRS; 25000-4000 cm-1), Fourier-transform infrared spectroscopy in the mid-IR region (FTIR; 3750-400 cm-1) and a combined Fourier-transformed infrared – thermal programmed desorption technique (FTIR-TPD; 3750-400 cm-1) – to Holocene sediment records from two Swedish lakes, Lång-Älgsjön and Lake Koukkel, to reconstruct past changes in the organic matter composition. The infrared spectral information of these records indicate sections of different organic matter composition reflecting varying stages of the lake and landscape development. An early-Holocene mire development around the boreal lake Lång-Älgsjön led to an increased input of organic matter from the catchment into the lake initiating an early natural lake acidification, whereas the subarctic Lake Koukkel has been affected by mire and potentially late-Holocene permafrost dynamics, which caused an increased and less variable input of allochthonous organic matter. Overall, variations in organic matter composition seem mainly driven by changes in the landscape rather than any direct effects of successive climate changes.

Our findings emphasize that infrared spectroscopic methods are a promising tool for the fast and cost-effective characterization of organic matter in sediment samples, particularly with regard to the detection of qualitative differences between samples. An improved understanding of past variations in the organic matter composition and the related processes driving these changes is essential to further understand the interactions in the carbon cycle between the terrestrial and aquatic systems.