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Tracing terrestrial organic matter by delta34S and delta13C signatures in a subarctic estuary

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The fate of terrestrially derived organic carbon in the marine environment is poorly understood. One significant problem has been to precisely estimate the fraction of terrestrially derived carbon in marine dissolved organic matter (DOM). Stable isotopes, especially ^{13}C, have been widely used to trace the origin and fate of DOM. However, the isotopic range for delta^{13}C between the terrestrial and the marine sources of carbon to the ocean is rather small, only 6‰Ẇe have developed a method using delta^{34}S signatures, in addition to delta^{13}C signatures, to trace DOM in coastal environments. The stable isotope signatures for dissolved organic sulphur (delta$^{34}S_{DOS}$) have twice the range between terrestrial and marine endmembers compared to the stable isotope signatures for dissolved organic carbon (delta$^{13}C_{DOC}$); hence, the share of terrestrial DOM in the total estuarine DOM can be calculated more precisely. Another advantage with using delta$^{34}S_{DOS}$ is that estuarine primary production will also have a typical marine delta^{34}S signature, which will make it possible to distinguish terrestrial organic matter from both marine- and estuarine-produced organic matter. In contrast, a significant fraction of the carbon in estuarine primary production can be assimilated terrestrial DIC, which cannot be readily distinguished from terrestrially derived organic matter in an estuary. We therefore calculated the fractions of the estuarine DOC that is terrestrially derived in the Northern Baltic Sea from both delta$^{13}C_{DOC}$ and delta$^{34}S_{DOS}$ signatures. While the fractions can be calculated directly from the delta$^{13}C_{DOC}$ signatures, the delta$^{34}S_{DOS}$ signatures must be combined with the C:S ratios from both the riverine and marine endmembers. The delta$^{34}S_{DOS}$ signature of the riverine endmember was measured to be +7.02‰ and the marine endmember was taken to be delta$^{34}S_{DOS}$ =18.1‰Ṫhe mean signatures from Bothnian Bay, Bothnian Sea, and the Baltic Proper were +10.27, +12.51, and +13.67‰ respectively, showing an increasing marine signal southwards with increasing salinity. These signatures indicate that 87%, 75%, and 67%, respectively, of the water column DOC are of terrestrial origin in these basins. Comparing the fractions of terrestrially derived DOC in each basin with the annual river input of DOC, it appears that the turnover time for terrestrial derived DOC in the Gulf of Bothnia is much shorter than the hydraulic turnover time, suggesting that high latitude estuaries are efficient sinks for terrestrial derived DOC.