Colored dissolved organic matter and dissolved organic carbon exclusion from lake ice: Implications for irradiance transmission and carbon cycling

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ABSTRACT: Thick ice cover is a feature of cold-temperate, polar, and alpine lakes and rivers throughout much of the year. Our observations from Canadian lakes and rivers across the latitudinal gradient 46-80° N show that their overlying ice contains low concentrations of dissolved organic carbon (DOC) and colored dissolved organic matter (CDOM) relative to the underlying waters. The CDOM exclusion factor (water/ice) ranged from 1.4 to 114 and was typically greater than twice the exclusion factor for inorganic solutes. Application of synchronous fluorescence analysis to lake ice samples and experimentally frozen lakewater indicated that only less complex, lower molecular weight molecules were retained within the ice. Consistent with this analysis, DOC-specific absorption showed that the DOC in the ice was generally less colored than that in the underlying waters. The reduced CDOM absorption within the ice allowed relatively high ultraviolet (UV) transmission despite the elevated scattering within the ice and resulted in UV diffuse attenuation coefficients up to eight times lower in the ice than in the underlying waters. This relatively low attenuation by the ice would cause organisms trapped near the surface by inverse stratification to experience high UV exposure prior to ice breakup. The ice exclusion effect gives rise to a concentrated zone of CDOM and DOC that is likely to favor heterotrophic and mixotrophic processes and influence biogeochemical interactions.

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