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Lake brownification and eutrophication effects on DOM dynamics

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Brownification by dissolved organic matter of terrestrial origin (tDOM) and eutrophication caused by excessive phosphorus loading, are two prominent anthropogenic pressures on lakes. Brownification and eutrophication may occur simultaneously and also influence DOM release by primary producers, thus affecting DOM dynamics both directly and indirectly. In a large-scale enclosure experiment conducted in a nutrient-poor clear-water lake (Lake Stechlin in northeastern, Germany; www.lake-lab.de), we created three levels of DOM concentrations (addition of 0, 3 and 10 mg/L) along a gradient of seven phosphorus levels (targeted starting concentration of 18, 19, 22, 27, 34, 43, and 54 μg/l). Following a single addition of DOM and phosphorus, we determined DOM composition by fluorescent and spectrophotometric analyses over 6 weeks. In addition, we monitored total nitrogen, total phosphorus and chlorophyll-a concentrations. Nutrient concentrations in the fertilized enclosures returned to lake levels within 4 weeks in the absence of added DOM, but remained elevated in both brownification treatments throughout the experiment. Phosphorus addition facilitated algal development, which increased the proportion of autochthonous fluorescent components. This buffered the effect of humic DOM addition by reducing its contribution to the overall DOM pool. In all treatments, we observed a cycle of autochthonous organic matter production and consumption with peaks observed after 3 and 6 weeks, respectively. Phosphorus fertilization accelerated this cycle by up to one week, and an interaction between factors affected the timing of autochthonous DOM production: in brownification treatments, earlier peaks of autochthonous DOM were observed in enclosures receiving DOM at low levels of phosphorus addition. These results highlight the importance of interactions between terrestrially-derived DOM and nutrient inputs in lakes on DOM dynamics.