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Salinization increases phosphorus internal loading in freshwater urban lakes

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Accelerating urban growth worldwide has generated great concern for declining water quality and eutrophication in freshwater urban lakes. Eutrophication is generally assumed to be driven by the human-enhanced supply of the limiting nutrient element phosphorus (P). Salinization is another stressor for urban freshwater quality and, in cold climate regions, it is most often caused by the runoff of salt applied on roads as de-icing agents during the winter. While the ecological damages caused by P enrichment and salinization to freshwaters are well established, thus far, their impacts on water quality have been considered separately. Although strict controls have led to decreases in P inputs to freshwater systems, many lakes in North America, as well as worldwide, have remained in eutrophic states, as indicated by declining dissolved oxygen (DO) concentration and rising dissolved inorganic P (DIP) in their hypolimnions. Our previous study of an urban freshwater lake in Ontario, Canada, showed that persistent eutrophication symptoms are linked to salinization associated with impervious land cover expansion, rather than high external P loading. In this research, we present a multiple decade of water chemistry data analyses for several other urban lakes in Ontario, Wisconsin, and Minnesota to identify more cases where salinization is promoting eutrophication symptoms. Our trend analysis shows progressive salinization (observed through significant increases in chloride or electrical conductivity) of all the lakes investigated, which strengthens their thermal stratification (calculated using the Brunt-Väisälä frequency). The increasing salinity trends are also accompanied by increasing hypolimnion hypoxia and increasing DIP to total P ratios in all the lakes. These datasets therefore provide more examples of urban lakes where eutrophication symptoms are promoted by salinization. Rising salinity intensifies water column stratification, in turn, reducing the oxygenation of the hypolimnion that enhances internal P loading from the sediments. These results highlight that stricter controls on the application and runoff of de-icing salts should be considered as part of managing lake eutrophication symptoms in cold climate regions.