Salinization increases eutrophication symptoms in freshwater lakes of North America

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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 it is most often caused by the runoff of salt applied on roads as de-icing agents during the winter in cold climate regions. 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 urban stormwater and wastewater management have decreased 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) concentrations and rising dissolved inorganic P (DIP) concentrations in their hypolimnions. Here we present an analysis of multiple decades of water chemistry data for several urban lakes in North America (Ontario, Wisconsin, and Minnesota) to demonstrate that elevated salinization associated with impervious land cover expansion, is causing the observed increasing anoxia and prevalence of internal P loading observed in the lake 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 accompanied by increasing hypolimnion hypoxia and increasing DIP to total P ratios in all the lakes, therefore demonstrating that the eutrophication symptoms are being promoted by salinization. Rising salinity intensifies water column stratification, in turn, reducing the oxygenation of the hypolimnion and enhancing internal P loading from the sediments. These results highlight that stricter management on de-icing salt application rates should be considered to control lake eutrophication symptoms in cold climate regions.