Temporal and spatial patterns of Cl^- and Na^+ concentrations and selected solutes in salted urban watersheds

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The study of sodium and chloride in the environment has a long history, with a particular focus on road salting in urban areas. In many previous studies, spatial scales are limited (e.g., city) and temporal measurements are coarse (e.g., monthly), such that our understanding of the hydrogeochemical dynamics is limited. Through a unique set of spatial and temporal measurements from the State of Michigan we a) examine the spatial distribution of chloride across a broad geographic area, b) explore the temporal behavior of sodium, chloride, nitrate, potssium and DOC over hydrologic events capturing both snowmelt and rain through salting seasons, and c) explore the use of chloride/sodium ratios as a tool for linking sources to concentrations. Results show that 1) distributions of chloride concentrations in wells across the landscape clearly show the fingerprint of human activities and the impact of urban areas and roads, as well as evidence for the upwelling of brine; 2) changes in concentration patterns and first-flush characteristics of the solutes differ over the hydrographs as a function of salting and post-salting periods, and as a function of event (e.g. snow melt, rain) which are interpreted to be related to changes in flow pathways; 3) chloride/sodium ratios do not clearly indicate a halite source and can be very high (>5) which is interpreted to be the result of their different environmental behaviors, which can decouple their relationship (e.g., during salting periods both are quickly removed from the landscape during first flush and diluted as event water begins to dominate, while in post salting periods only chloride is diluted) and to the type of road salt applied. The results may help define the concentration limits of sodium and chloride in the environment. These two solutes are easily measured indicators of human influence on the environment and measurements of their spatial and temporal concentraton patterns should continue. However, we suggest more research is necessary to better understand their cycling on shorter time scales and how this knowledge can be used to inform our understanding of other chemical cycles in the environment.