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Method for estimating road salt contamination of Norwegian lakes

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Consumption of road salt in Norway, used to improve winter road conditions, has been tripled during the last two decades, and there is a need to quantify limits for optimal use of road salt to avoid further environmental harm. The purpose of this study was to implement methodology to estimate chloride concentration in any given water body in Norway. This goal is feasible to achieve if the complexity of solute transport in the landscape is simplified. The idea was to keep computations as simple as possible to be able to increase spatial resolution of input functions. The first simplification we made was to treat all roads exposed to regular salt application as steady state sources of sodium chloride. This is valid if new road salt is applied before previous contamination is removed through precipitation. The main reasons for this assumption are the significant retention capacity of vegetation; organic matter; and soil. The second simplification we made was that the groundwater table is close to the surface. This assumption is valid for major part of Norway, which means that topography is sufficient to delineate catchment area at any location in the landscape. Given these two assumptions, we applied spatial functions of mass load (mass NaCl pr. time unit) and conditional estimates of normal water balance (volume of water pr. time unit) to calculate steady state chloride concentration along the lake perimeter. Spatial resolution of mass load and estimated concentration along the lake perimeter was 25 m x 25 m while water balance had 1 km x 1 km resolution.

The method was validated for a limited number of Norwegian lakes and estimation results have been compared to observations. Initial results indicate significant overlap between measurements and estimations, but only for lakes where the road salt is the major contribution for chloride contamination. For lakes in catchments with high subsurface transmissivity, the groundwater table is not necessarily following the terrain surface, thus the assumption of catchment delineation based on topography alone is not valid, which means that the local mass balance is not correct. An administrative challenge is to improve monitoring of spatially distributed road salt application. Another major challenge is to increase spatial resolution of water balance and quantify the spatial uncertainty. As soon as spatiotemporal water balance is available, a similar approach may be used to solve a simplified time dependent transport equation. So far the steady-state algorithm has been implemented in a Web-GIS application and is taken into operational use by the Norwegian Public Roads Administration for management of Norwegian roads during winter condition.