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Road Salts in Urban Stormwater: an Emerging issue in Stormwater Management in Cold Climate

By:

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ROAD SALTS IN URBAN STORMWATER: AN EMERGING ISSUE IN STORMWATER MANAGEMENT IN COLD CLIMATE

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Abstract

Potential impacts of road salting on the environment have increased by introduction of stormwater management practices. Specific impacts are discussed for four such practices, infiltration facilities, oil and grit separators, stormwater ponds and constructed wetlands. The main concerns about (hazards of) chloride-laden stormwater discharges include contamination of groundwater, leaching out of trace metals, densimetric stratification and poor vertical mixing in ponds, direct and indirect toxic effects, benthic drift and reduced biodiversity. The associated environmental risks need to be reduced by chloride source controls, and prevention of excessive chloride accumulations by appropriate design and operation of stormwater facilities in winter months.

LES SELS DE VOIRIE DANS LES EAUX PLUVIALES URBAINES : UN NOUVEL ENJEU POUR LA GESTION DES EAUX PLUVIALES DANS LES CLIMATS FROIDS

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Résumé

Les possibles impacts de l'épandage de sels de voirie sur l'environnement se sont amplifiés par suite de la mise en œuvre de certaines pratiques de gestion des eaux pluviales. Les impacts particuliers sont examinés pour quatre de ces pratiques, à savoir les bassins d'infiltration, les dessableurs-dégraisseurs, les bassins d'eaux pluviales et les marais artificiels. Les principales préoccupations (risques) concernant les rejets d'eaux pluviales chargées de chlorure comprennent la contamination des eaux souterraines, le lessivage des métaux traces, la stratification densimétrique et un mélange vertical médiocre dans les bassins, des effets toxiques directs et indirects, une dérive benthique et une biodiversité réduite. Les risques environnementaux connexes doivent être réduits grâce à l'élimination des chlorures à la source et à la prévention d'accumulations excessives de chlorures au moyen d'un paramétrage approprié et de l'utilisation adéquate des installations pour eaux pluviales pendant les mois d'hiver.

NWRI RESEARCH SUMMARY

Plain language title

Road salts in urban stormwater: an emerging issue in stormwater management in cold climate

What is the problem and what do sicentists already know about it?

Potential impacts of road salting on the environment have increased by introduction of such stormwater management practices as infiltration, oil and grit separators, ponds and constructed wetlands. The associated environmental risks need to be reduced by salt source controls, and appropriate stormwater management design and operation during winter months.

Why did NWRI do this study?

NWRI has been working on improving the understanding of stormwater pollution and the best management practises (BMPs) for controlling such a pollution. Developing new knowledge on entry of chloride into stormwater and environmental effects of discharges of salt-laden stormwater during winter months will supplement the earlier research and contribute to a better BMP design taking into account the presence of road salts.

What were the results?

A number of environmental concerns have been identified - contamination of groundwater by infiltration of chloride-laden stormwater, leaching out of trace metals, densimetric stratification and poor vertical mixing in stormwater ponds, direct and indirect toxic effects, benthic drift and reduced biodiversity. The associated environmental risks need to be reduced by chloride source controls, and prevention of excessive chloride accumulations by appropriate design and operation of stormwater management facilities during winter months.

How will these results be used?

These results will be used by water pollution control planners and municipal engineers in controlling winter snowmelt and runoff pollution.

Who were our main partners in the study?

No partners have been engaged in this study.

Sommaire des recherches de l'INRE

Titre en langage clair
Les sels de voirie dans les eaux pluviales urbaines : un nouvel enjeu pour la gestion des eaux pluviales dans les climats froids.

Quel est le problème et que savent les chercheurs à ce sujet?
Les possibles impacts de l'épandage de sels de voirie sur l'environnement ont augmenté par suite de la mise en œuvre de certaines pratiques de gestion des eaux pluviales, comme les bassins d'infiltration, les dessableurs-dégraisseurs, les bassins d'eaux pluviales et les marais artificiels. Les risques environnementaux connexes doivent être réduits grâce à l'élimination des sels à la source ainsi qu'à un paramétrage approprié et à l'utilisation adéquate des installations pour eaux pluviales pendant les mois d'hiver.

Pourquoi l'INRE a-t-il effectué cette étude?
L'INRE a effectué des recherches pour mieux comprendre la pollution par les eaux pluviales et rendre encore plus efficaces les pratiques de gestion optimales (PGO) pour combattre cette pollution. L'obtention de nouvelles données sur l'entrée du chlorure dans les eaux pluviales et les effets environnementaux de la décharge d'eaux pluviales renfermant du sel pendant les mois d'hiver complétera les recherches antérieures et contribuera à rendre encore plus efficace les PGO en tenant compte de la présence des sels de voirie.

Quels sont les résultats?
Un certain nombre de préoccupations environnementales ont été identifiées : la contamination des eaux souterraines par infiltration d'eaux pluviales renfermant du chlorure, le lessivage des métaux traces, la stratification densimétrique et un mélange vertical médiocre dans les bassins d'eaux pluviales, des effets toxiques directs et indirects, une dérive benthique et une biodiversité réduite. Les risques environnementaux connexes doivent être réduits grâce à l'élimination des chlorures à la source et à la prévention d'accumulations excessives de chlorures ainsi qu'au paramétrage approprié et à l'utilisation adéquate des installations pour eaux pluviales pendant les mois d'hiver.

Comment ces résultats seront-ils utilisés?
Ces résultats serviront aux planificateurs de la dépollution de l'eau et aux ingénieurs municipaux pour combattre la pollution générée par la fonte de la neige et le ruissellement.

Quels étaient nos principaux partenaires dans cette étude?
Aucun partenaire n'a été engagé pour cette étude.

ROAD SALTS IN URBAN STORMWATER: AN EMERGING ISSUE IN STORMWATER MANAGEMENT IN COLD CLIMATE

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Potential impacts of road salting on the environment have increased by introduction of stormwater management practices. Specific impacts are discussed for four such practices, infiltration facilities, oil and grit separators, stormwater ponds and constructed wetlands. The main concerns about (hazards of) chloride-laden stormwater discharges include contamination of groundwater, leaching out of trace metals, densimetric stratification and poor vertical mixing in ponds, direct and indirect toxic effects, benthic drift and reduced biodiversity. The associated environmental risks need to be reduced by chloride source controls, and prevention of excessive chloride accumulations by appropriate design and operation of stormwater facilities in winter months.

Key Words: Road salts, chloride, stormwater management, infiltration, oil and grit separators, stormwater ponds and wetlands.

Introduction

Since the late 1940s, the policy of "bare pavement" has been adopted by many highway and road maintenance authorities in winter road maintenance and practised by applying road salts to pavement surfaces. Recently, the annual use of salt in road maintenance in Canada was estimated at about 5 million tonnes/y (1997-98 data)(EC&HC, 2001). Most commonly, sodium chloride (NaCl) is used, but other salts may be also used when lower eutectic temperatures are needed (calcium chloride $CaCl_2$, or magnesium chloride $MgCl_2$). Salt substitutes (e.g., CMA, calcium magnesium acetate) have been studied, but so far found less effective and/or much more costly (Novotny *et al.*, 1999; TRB, 1991).

The common road salt used in de-icing contains primarily sodium chloride (40% sodium and 60% chloride, by weight), an anti-clumping agent ferrocyanide, and trace elements (impurities), which may represent up to 5% of total salt weight (mostly phosphorus, sulphur, nitrogen, copper and zinc). Where salt is used in a mixture with abrasives, additional chemicals may be contained in the abrasives. About one half of applied salts enters surface runoff at the site of applications, and the other half is either removed with used snow, or incorporated into soils or transported into groundwater (EC&HC, 2001). Sodium chloride is readily soluble in water, where it forms sodium and chloride ions in solution (Na^+, Cl^-). The chloride ion is extremely mobile and conservative; it does not readily react with other chemicals or adsorb significantly on mineral surfaces. Thus, its transport through the environment is essentially based on physical processes (transport, dilution, concentration)(EC&HC, 2001).

Large amounts of salts are annually released into the environment (Mayer *et al.*, 1999b), with many environmental implications arising from salt effects on soils (Amrhein *et al.*, 1992), vegetation (Isabelle *et al.*, 1987), and infrastructure (Lord, 1989); physical and water quality processes in receiving waters (Marsalek, 1997; Novotny *et al.*, 1999), sources of drinking water (EC&HC, 2001), biological communities in receiving waters, and biodiversity (Crowther and Hynes, 1987).

Environmental effects of road salting represent an old issue (Field *et al.*, 1974), of which importance recently greatly increased in view of the Environment Canada and Health Canada assessment of road salts as "toxic" under the Canadian Environmental Protection Act (EC&HC, 2001). Also, during the past 30 years, the environmental effects of salt on smaller receiving water bodies may have increased in modern stormwater management systems. In such systems, urban runoff may be infiltrated into groundwater, or be treated in water quality inlets with limited flushing, or be stored and routed through stormwater ponds and constructed wetlands designed to provide recreational and ecological amenities (MOEE, 1994; Schueler, 1987). Such concerns have not been adequately addressed in the literature on stormwater management or in design of best management practices, which have been largely developed in regions without road salting problems (Caraco and Claytor, 1997). Thus, the main purpose of the paper that follows is to explore the issue of road salts from the point of view of urban drainage and stormwater management.

Chloride fate in stormwater management facilities

In conventional urban drainage, without stormwater management, chloride originating in road salting was mostly transported by overland flow to sewers and nearby receiving waters. Other chloride pathways included infiltration of chloride-laden runoff into soils and groundwater, drainage of overland flow directly into receiving waters, and transport of Cl with removed snow to snow dumps or disposal sites in open waters. These pathways are strongly modified by stormwater management, particularly in structural best management practices (BMPs). The following discussion concentrates on four types of BMPs, infiltration facilities, oil and grit separators, stormwater ponds, and constructed wetlands.

Stormwater infiltration facilities

Stormwater infiltration facilities serve to reduce the volume and rate of runoff, reduce pollutant transport and export, and recharge groundwater (MOEE, 1994). They are designed in various forms, including wells (pits), trenches, basins, porous pavement, and perforated pipes and drainage structures (catch basins, inlets, and manholes), often equipped with some pre-treatment measures (Schueler, 1987).

Environmental concerns about stormwater infiltration were addressed by Mikkelsen *et al.* (2001) with respect to the risk assessment of stormwater contaminants and hazard assessment of stormwater infiltration. They identified a number of challenges, including difficulties with chemical characterisation of stormwater pollutants, high numbers of substances present (some of which exert unknown effects), and extreme variations of concentrations. Stormwater contaminants were assessed by comparison against the environmental water quality limits for soils (preserving fertility and structure, protecting children against poisoning via soil ingestion), groundwater (preserving water quality required for potable water sources), and surface water (preventing acute toxicity to aquatic organisms and plants, and preventing chronic toxicity to plants and benthic organisms). Infiltration of chloride-laden runoff may cause concerns with respect to all the above water quality limits (Pitt *et al.*, 1999).

With respect to soils, chloride adversely affects soil fertility, by impacting on soil structure and water transport through the soil. Sodium ions (Na^+) may replace Ca^{2+} and Mg^{2+} cations and leach out trace metals, which may contaminate the groundwater (Amrhein *et al.*, 1992). Clays with sites primarily occupied by sodium tend to be cohesive and impermeable (Krauskopf, 1995). Chloride also impacts on drinking source water.

Health Canada and Environment Canada (1995) drinking water quality guidelines recommend limits for chloride (total) ≤250 mg/L and sodium ≤200 mg/L. Other guidelines may call for much lower limits, e.g., 25 mg/L of chloride (recommended by the U.S. Public Health Service, cited in D'Itri, 1992), and ≤20 mg/L of sodium (sodium restricted diets; Madison Department of Public Health, 2000). These reduced limits may be exceeded in wells exposed to inflow of chloride, as reported e.g., in Madison, Wisconsin, where chloride and sodium concentrations in water utility deep wells were on average 54.4 mg/L and 22.0 mg/L, respectively, between 1989 and 1999 (Madison Department of Public Health, 2000). The annual cost of chloride removal by source water treatment was estimated at 10 million in the US Northeast and Midwest (TRB, 1991). In the Minneapolis/St. Paul area, chloride concentrations ranged from 4 to 330 mg/L in 30 water table wells located in unconfined sand and gravel aquifers, with the highest values found downgradient of major highways (Andrews *et al.*, 1999).

Chloride transport through shallow groundwater aquifers in urban areas is reflected in high Cl concentrations in baseflow of urban streams. Williams *et al.* (2000) reported Cl peaks up to 1390 mg/L in Highland Creek (Toronto); Bowen and Hinton (1998) reported increases in Cl concentrations in Highland Creek baseflow from 150 mg/L in 1972 to about 250 mg/L in 1995, and Howard and Haynes (1997) estimated that baseflow concentrations would reach 400 mg/L of chloride in urban watercourses in the Toronto area within a 20-year time frame. In the same metropolitan area, Williams *et al.* (2000) observed chloride levels in 23 springs (not used for water supply) ranging from < 2 to > 1200 mg/L. All these studies found chloride contamination to be rising and related to urbanisation.

Thus, stormwater infiltration facilities receiving chloride-laden stormwater would contribute to environmental hazards with respect to groundwater contamination and leaching out of metals, and the permeability of such facilities could be reduced by chloride interference with soil structures. The actual risk would have to be mitigated by controlling the chloride use in vulnerable areas, focusing on infiltration of relatively chloride-free, clean runoff (e.g., from roofs), and restricting infiltration practices to the areas with limited uses of groundwater.

<u>Oil and grit separators</u>

The oil and grit separators (OGS) provide some stormwater treatment by sedimentation and skimming of floatables (free oil). Individual designs range from simple three-chamber settling tanks (Schueler, 1987) to sophisticated designs with packing balls enhancing removal of volatiles, a settling chamber with tube settlers and oil sorbent pillows, and an outflow chamber with filter media (Pitt *et al.*, 1999). While all OGSs show good potential for removing coarse solids (sand) and partial containment of free oil spills (MOEE, 1994), their actual field performance is poorly known and obscured by incomplete performance data without the characteristics of stormwater treated (e.g., solids concentrations and particle size distributions) and hydraulic residence times (Greb *et al.*, 1998). Typical units may be 1.5 to 3 m deep, and provide residence times of 6-12 minutes, with surface loading rates of 7.5-30 m/h.

Some OGSs are designed to prevent resuspension of trapped materials by providing deep storage compartments, with inlet and outlet points located close to the top of the compartment. Several studies indicated that these designs tend to accumulate dissolved solids and particularly chloride. Henry *et al.* (1999) measured conductivity in a 3-chamber OGS and a manhole-type OGSs. In the first one, there was no chemo-stratification, but in the second device, a high-density layer was found at about 1.6 m below the top of the tank. The layer receded to the bottom in the summer, disappeared in late fall, and reappeared in winter. The conductivity and chloride concentration measured during the winter season were found to be 72.7 mS/cm and 36,500 mg/L, respectively. Similar findings were reported by SWAMP (1999) for two OGSs, in which conductivity increased dramatically at 1.5-2.0 m below the water surface. Finally, in a study of an OGS in a works yard with poorly protected salt storage, over the bottom 0.9 m, TDS increased from 51,000 to 138,000 mg/L (Greb *et al.*, 1998).

Conductivity readings for stormwater ponds and one OGS (Marsalek, 1997; Mayer *et al.*, 1999; SWAMP, 1999) are presented in Fig. 1 in dimensionless graphs of relative Total Dissolved Solids (TDS_d/TDS_D = $conductivity_d/conductivity_D$) vs. relative depth (d/D), where d is the variable depth below the water surface and D is the maximum depth.

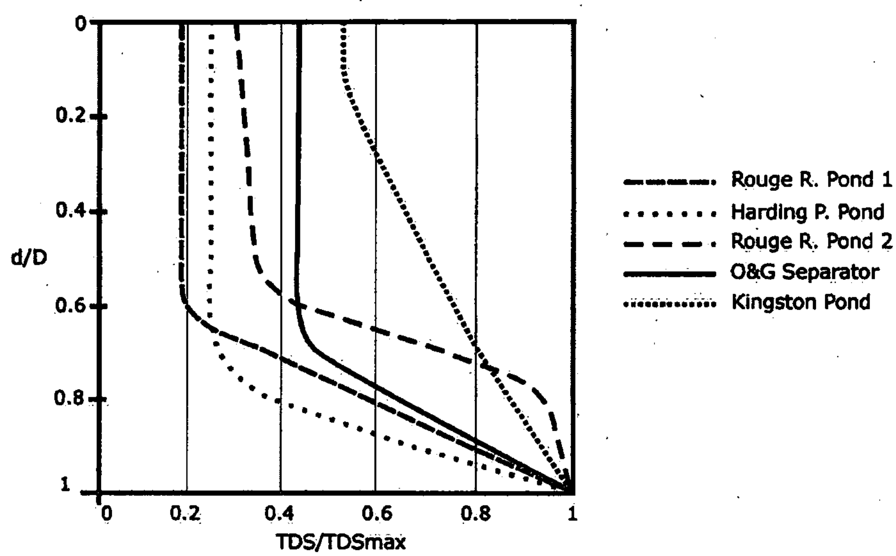

Fig. 1. Relative concentrations of total dissolved solids (TDS_d/TDS_D) vs. dimensionless depth (d/D)

The TDS distribution for the OGS in Fig. 1 shows a layer of constant density followed by a bottom layer with continually increasing density. It can be estimated that in winter about 30-40% of TDS is chloride (Marsalek, 1997; SWAMP, 1999).

Chloride accumulations in OGSs have a number of environmental implications: (a) interference with removal of fine suspended solids (the dense bottom layer may be "impenetrable" to the incoming stormwater), (b) potential generation of chloride shock loadings on downstream areas, and (c) interference of chlorides with sediment trapped on the bottom of OGS, with potential metal leaching and impacts on downstream areas. In cold climate with road salting, these issues require further research.

Stormwater management ponds.

Stormwater ponds are widely used in stormwater management to provide flow control (reduction of flow peaks), sedimentation (removing sand, and some silt and clay), removal of dissolved pollutants by aquatic plants, and provision of aesthetic and recreational amenities (Schueler, 1987). Pond structural components include an inlet (spreading the influent), sediment forebay (easily accessible for maintenance), outlet (preferably a perforated riser), outfall (protected by riprap) and an emergency overflow usually designed for a 100-yr flood. Ponds have a distinct feature among BMPs – depending on the point of view, they are seen as both desirable recreational/ecological amenities and water treatment devices (Anderson *et al.*, 2002). Obviously in many instances it is difficult to reconcile these conflicting expectations (Bishop *et al.*, 2000a,b).

In connection with road salting, the first concerns about chloride impacts on small impoundments were published by Judd (1970) who noted chemo-stratification in First Sister Lake in Michigan. For stormwater ponds, Marsalek (1997) and Marsalek *et al.* (2000) reported accumulation of TDS and chloride in the Kingston Pond and produced continuous conductivity measurements indicating cycling of TDS and chloride in the pond; accumulation in the winter, with an expedient flushing out in the spring. Mayer *et al.* (1999) observed a strong conductivity gradient in a Toronto area stormwater pond, with readings of 1.65 mS/cm 0.5 m below the surface and increasing to 9.0 close to bottom (TDS = 1,060-5,760 mg/L), at the depth of 4.0 m, and similar findings were reported for the same facility by SWAMP (1999).

Relative concentrations of TDS vs. depth are plotted in Fig. 1 for three ponds, Harding Park Pond (SWAMP, 1999), Kingston Pond (Marsalek, 1997), and Rouge River Pond (the first data set after Mayer *et al.*, 1999; the second set after SWAMP, 1999). These graphs indicate strong densimetric stratification of all ponds, with lowest concentrations at the water surface representing 0.2-0.5 of the bottom concentrations. The Kingston on-stream pond had the weakest stratification (Marsalek *et al.*, 2000); repeated measurements in the pond indicated that with strong inflows, the ice-covered pond can be de-stratified quickly (Marsalek, 1997). Two measurements in the Rouge River Pond indicate two states of stratification, with about the same maximum TDS concentrations; the second set of measurements shows reduced stratification.

In regions with road salting, ponds have distinct chloride regimes. In summer and fall, stormwater ponds are fed by runoff and/or creek streamflow with relatively low Cl concentrations (< 100 mg/L) representing natural sources of Cl or washout from soils and shallow aquifers (Bowen and Hinton, 1998). With the onset of salting operations (late fall/early winter), concentrations of TDS and chloride in runoff dramatically increase, as a result of preferential elution from snowpacks, with Cl concentrations 5-10 larger than average concentrations in the snowpack (Westerstrom, 1995, Viklander, 1997; Oberts *et al.*, 2000). Incoming chloride-laden stormwater enters the pond at various stratas, depending on its TDS burden and in-pond stratification. Thus, flow may enter as a buoyant jet, or interflow, or sinking jet (Marsalek, 1997). Depending on local sources, chloride concentrations in the pond increase during the winter and peak sometimes between mid January and mid March. In the relatively shallow Kingston pond, Cl concentrations near bottom reached 1,000 mg/L and 1,300 mg/L in interstitial water. Much of the chloride burden was released with the first major flow event, usually in late March (Marsalek, 1997). Off-line ponds are not subject to the same intensity of flushing and would retain chloride loads much longer, possibly year round, with gradual long-term increases (SWAMP, 1999).

The pond chloride regime has a number of environmental implications: (a) strong stratification inhibits vertical mixing and aeration of bottom layers (particularly in off-line ponds), (b) lack of oxygen in bottom layers and high concentrations of chloride lead to chemical processes, which may stimulate releases of chemicals from bottom sediment, and (c) high chloride concentrations may cause toxic effects on certain types of biota inhabiting ponds. The above impacts can be mitigated by controlled use of road salts (source controls) and a pond design reducing chloride accumulation, or facilitating regular Cl releases in winter months through bottom outlets.

<u>Constructed wetlands.</u>

Constructed wetlands provide stormwater detention and treatment by various processes, including filtration, infiltration, and biosorption, and remove both particulate and dissolved pollutants (Rochfort *et al.*, 1997). The problems associated with this BMP include thermal enhancement, seasonal variations in performance, poor performance during winter months, and complicated maintenance (MOEE, 1994). Effects of chlorides on constructed wetlands used in stormwater management are not well understood, but in view of low water depths in wetlands, it is unlikely that there would be a significant risk of chloride accumulation.

Salt-laden runoff impacts on roadside vegetation and wetland plants, though some plants may be resistant to such impacts. Isabelle *et al.* (1987) found that after one-month of exposure of wetland plant seeds to various mixes of meltwater, the germination and growth of seedlings were adversely affected by metals and oil/grease, with community biomass and productivity notably impacted. This suggests that discharge of meltwater to wetlands could cause species shifts to less desirable species (for example, *Typha latifolia* and *Lythrum salicaria*). Other effects of chloride on wetland plants and benthic communities can be deduced from the literature data, but without certainty that chloride, which is a general indicator of anthropogenic effects (Bowen and Hinton, 1998; Williams *et al.*, 2000), is the primary causative factor. Data abstracted from Bishop *et al.* (2000a) on numbers of aquatic plant species in one natural and seven man-made wetlands are shown in Fig. 2. Within the realm of above stated limitations, the numbers of plant taxa were inversely correlated with mean concentrations of chloride observed during the spring-fall seasons. The highest number of taxa (11) was observed in the natural wetland.

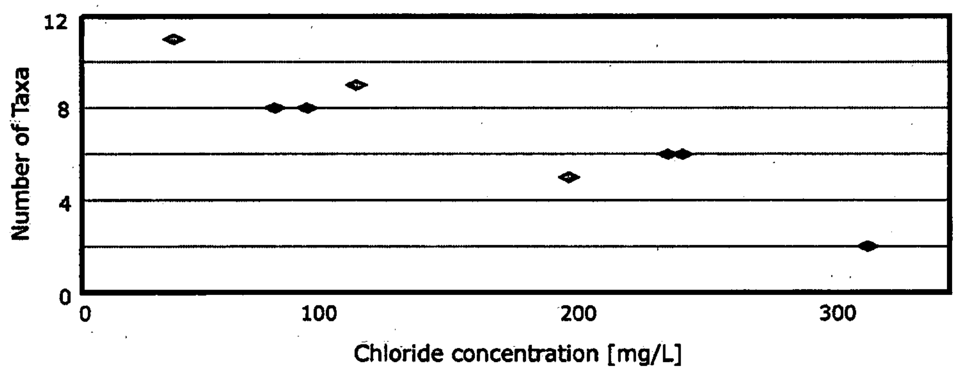

Fig. 2. Biodiversity of aquatic plants in wetlands vs. chloride concentrations (raw data after Bishop et al., 2000a)

Effects of chloride–laden stormwater on receiving water biota

The nature of road salting is such that its effects on water quality and biota in receiving waters can not be addressed just for chloride, but rather for chloride-laden stormwater, or road runoff. Such waters will contain a whole suite of anthropogenic pollutants and especially those related to traffic, including trace metals and hydrocarbons (Horkeby and Malmquist, 1977; Viklander, 1997; Oberts *et al.*, 2000). The presence of chlorides creates two types of effects – those exerted directly by chloride toxicity, and those caused by toxicity of urban pollutants which may be enhanced by chloride presence (e.g., leaching of contaminants or their increased bioavailability). In field studies, these two factors cannot be separated, as shown in Fig. 3 for toxicity of highway runoff in various seasons.

Studies of potential biotic impacts of chloride-laden runoff were conducted using chemical indices, bioassays (employing microorganisms, bio-particles, crustaceans, and fish), and biological communities. A summary of such research follows. Runoff samples from a major multi-lane divided highway were studied by Marsalek *et al.* (1999) and indicated increased toxicity during the winter months. In a similar study, Mayer *et al.* (1998) tested acute toxicity of runoff at the same site and also measured chloride concentrations. Data indicate acute toxicity during winter months with chloride concentrations as high as 19,100 mg/L. During runoff without snowmelt, only one case of acute toxicity (10% of organisms died) was observed.

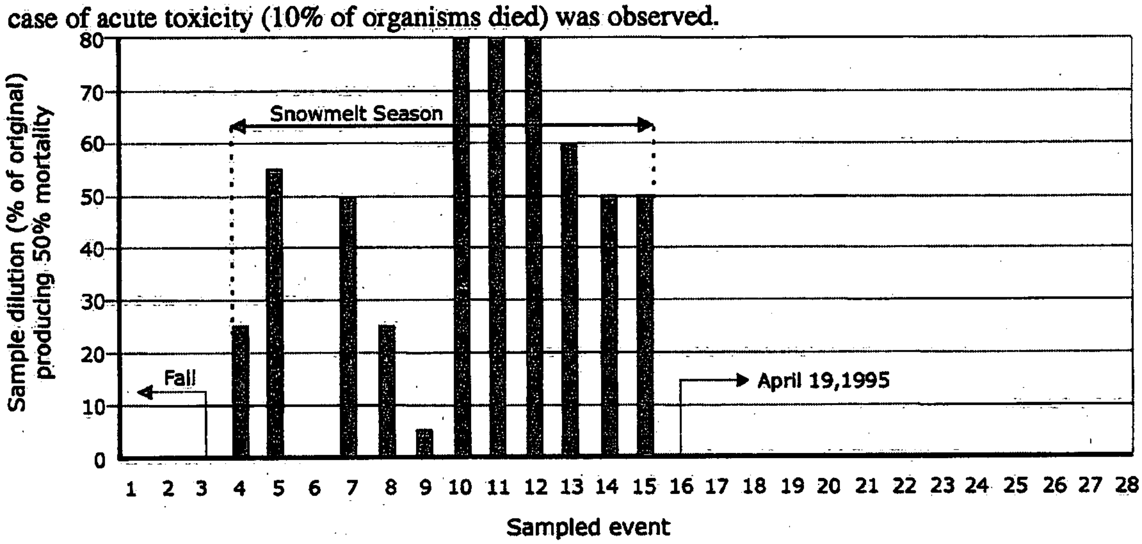

Fig. 3. Seasonal acute toxicity of highway runoff (based on 48-h *Daphnia magna* bioassay)

The above data indicate that winter snowmelt is the causal factor in observed toxic effects, but no identification of specific chemicals (i.e., chloride or other chemicals) can be made.

Mayer *et al.* (1999a) studied the toxicity of pore water from benthic sediments from a stormwater pond receiving high chloride loads from a major multi-lane divided highway. Pond water was chemically stratified, with TDS concentrations ranging 1,060-5,760 mg/L. Benthic toxicity tests (Hyalella Azteca, 7-day exposure) with pore water showed no survival for 100% pore water, and 25% survival at 25% solution. However, a 100% survival was observed for saline water (6,000 mg/L chloride in tap water) and indicated that toxicity was caused by other factors, most likely trace metals, than chloride. Geochemical speciation modelling showed that high chloride levels increased dissolved Cd levels and thereby contributed to pore water toxicity.

Crowther and Hynes (1977), Molles (1980) and Demers (1992) reported the effects of salt on benthic drift. In all cases, significant decrease in the diversity of benthic communities was observed in streams receiving salt-laden runoff.

Delisle *et al.* (1997) used a potential ecotoxic effects probe, a factor synthesising physico-chemical data of snow, and concluded that snow potentially exhibited low toxic effects. White and Rasmussen (1995) tested genotoxicity of snow samples and found positive responses along major traffic routes. Winter highway runoff was also found toxic by Rokosh *et al.* (1997), who besides automotive fluids identified high levels of chloride as one of the causes of toxicity. Other data were summarised by Novotny *et al.* (1999), who also examined the problems associated with cyanide additive in commercial road salt.

U.S. EPA criteria list a number of toxicity thresholds for chloride, including: Chronic Freshwater Quality Criteria = 230 mg/L, the Secondary Maximum Contaminant Level of 250 mg/L, and Acute Freshwater Quality Criteria of 860 mg/L for small streamflow peaks resulting from snowmelt runoff (U.S. EPA, 1988; Novotny *et al.*, 1999). Generally it is acknowledged that there is a threshold of salt concentrations in receiving waters, below which any effects on aquatic biota (primarily fish and the food chain) are not detectable – about 1000 mg/L. For a short time, fish may withstand salt concentrations as high as 5000 mg/L (Novotny *et al.*, 1999).

Conclusions

Benefits derived from the use of salt in winter road maintenance need to be weighed against the associated environmental costs, well documented in the recent literature. Significant environmental effects are associated with high concentrations of chloride found in receiving waters during the periods of snowmelt. A scientific assessment of chloride effects on flowing waters is difficult because of large variations in chloride concentrations, dilution by mixing in receiving waters, and variation in organism exposures. Such an assessment is much easier in ponds and lakes, where chloride accumulates and contributes to chemostratification impeding vertical mixing. The risk of environmental effects of chlorides was increased in stormwater management facilities, which may discharge chloride-laden runoff to groundwater aquifers, create toxic conditions in ponds and possibly constructed wetlands, and contribute to pollutant release from bottom sediment by ionic exchange, leaching of metals and dissolved oxygen deficiency caused by chemical stratification and impeded vertical mixing. These water quality changes then contribute to the occurrence of toxic conditions (acute, chronic and genotoxic) in receiving waters, impaired performance of biological communities, and reduced biodiversity. Environmental benefits can be readily derived by smart use of de-icers and by adapting the design of stormwater BMPs to allow chloride dilution and passage at low concentrations (rather than accumulating Cl), and reducing or preventing Cl discharge to sensitive surface waters and groundwater.

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Sept. 24/03

Dianne, attached are comparisons of new and old abstracts for my two recent publications. Thanks for your help.

Regards,

Jiri Marsalek

NEW ABSTRACT

Road salts in urban stormwater: An emerging issue in stormwater management in cold climates

additions

J. Marsalek*

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Abstract

Potential impacts of road salting on the environment have increased by the introduction of certain stormwater management practices. Specific impacts are discussed for four such practices, infiltration facilities, oil and grit separators, stormwater ponds and constructed wetlands. The main concerns about the hazards of chloride-laden stormwater discharges include contamination of groundwater, leaching out of trace metals, densimetric stratification and poor vertical mixing in ponds, direct and indirect toxic effects, benthic drift and reduced biodiversity. The associated environmental risks need to be reduced by chloride source controls, and prevention of excessive chloride accumulations by appropriate design and operation of stormwater facilities in winter months.

Keywords: Road salts, chloride, stormwater management, infiltration, separators, ponds.

oil and grit — stormwater — DELETIONS: — and wetlands

OLD ABSTRACT:

ROAD SALTS IN URBAN STORMWATER: AN EMERGING ISSUE IN STORMWATER MANAGEMENT IN COLD CLIMATE

J. Marsalek*

National Water Research Institute, Burlington, ON L7R 4A6, Canada

Abstract

Potential impacts of road salting on the environment have increased by the introduction of stormwater management practices. Specific impacts are discussed for four such practices, infiltration facilities, oil and grit separators, stormwater ponds and constructed wetlands. The main concerns about the hazards of chloride-laden stormwater discharges include contamination of groundwater, leaching out of trace metals, densimetric stratification and poor vertical mixing in ponds, direct and indirect toxic effects, benthic drift and reduced biodiversity. The associated environmental risks need to be reduced by chloride source controls, and prevention of excessive chloride accumulations by appropriate design and operation of stormwater facilities in winter months.

Key Words: Road salts, chloride, stormwater management, infiltration, oil and grit separators, stormwater ponds and wetlands.

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Additional NWRI Authors: ____________
Authors: Marsalek, J.
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