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De-Icing Salt Levels in Toronto Stream Banks and Roadside Soils

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The escalating use of de-icing agents for minimizing the effects of winter storms and maintaining bare pavements, has been well documented. Growing concern has also been expressed about possible environmental side effects of these materials, and recent literature reviews have concluded that de-icing salts can cause injury and damage across a wide environmental spectrum (FIELD et al. 1974, HANES et al. 1970, USEPA 1971). This report presents data on salt levels in the roadside soils and stream banks of two stream systems.

The study areas are located on the northern boundary of Metropolitan Toronto within the watersheds of the Black Creek and Don River (Figure 1). Five soil sampling locations were chosen because they were close to major roads and were of reasonably level topography with very little slope either toward or away from the road. Samples were collected at varying depths and distances from the road edge during 1974 and 1975. At the stream bank sampling locations, a thin layer of soil, approximately 1 cm thick, was scraped from the bank just above the water line. Samples were collected both upstream and downstream from the road crossings on November 23, 1974 and again on February 27, 1975 after a thaw period when water levels were receding.

All soil and stream bank samples were air dried prior to the preparation of a 1:1 soil to water extract (JACKSON 1964) and this extract was then analyzed for water soluble sodium and chloride content with a Perkin Elmer, Model 103 atomic absorption spectrophotometer and a Technicon Auto-Analyzer II respectively.

RESULTS AND DISCUSSION

The presence of concentrations of both chloride and sodium in the soil adjacent to the road in the spring months, that are higher than "control" soils, indicates that road de-icing salts are infiltrating the roadside soils and causing elevated levels of these ions. However, at the locations sampled, the elevated levels of chloride and

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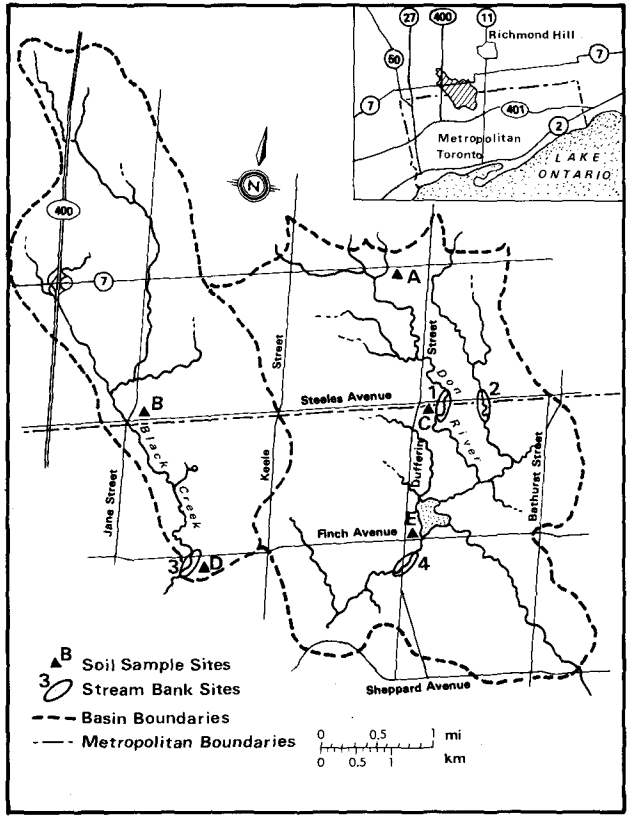

Figure 1. Location of study areas

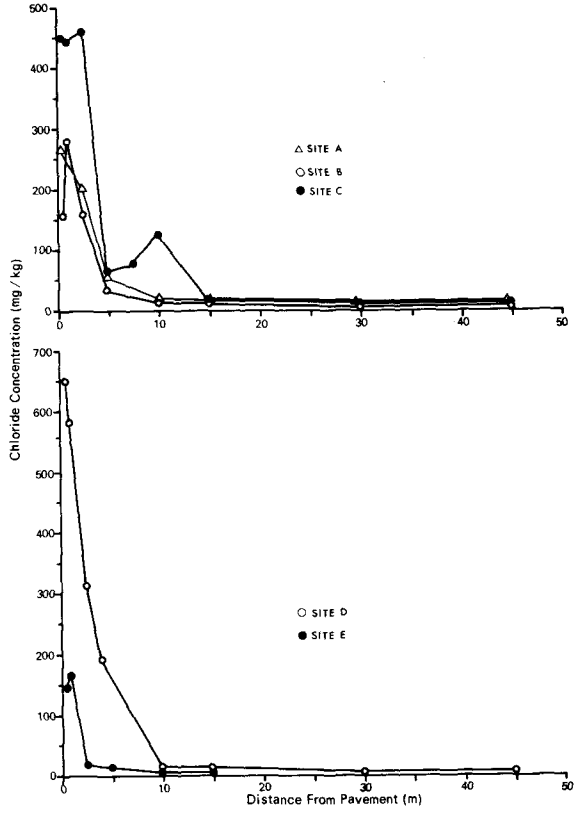

Figure 2. Variation in Cl content of roadside soil (0-20 cm depth) with distance from pavement

sodium appear to be limited to an area less than fifteen meters wide on each side of the pavement (Figure 2). Concentrations as high as 2,300 mg/kg (ppm) chloride and 1,900 mg/kg (ppm) sodium were measured in the soil adjacent to the road; while concentrations at distances of forty-five meters from the road averaged 8.7 mg/kg chloride and 13.9 mg/kg sodium.

Elevated chloride and sodium levels were measured at depths of 40-60 cm, indicating that the de-icing salts had percolated at least to this depth. Although the salts were leached downward (chloride especially), they were not totally removed before the next salting season. Even in October and November, the soil adjacent to the road contained chloride and sodium contents that were much higher than in control samples, suggesting that over a period of years, the salt content in the roadside soils may gradually increase. The data for Finch Avenue (Figure 2), illustrate this possibility when it is realized that the roadside soil at site E had only been exposed to de-icing salts for two winters because of adjacent landscaping; while the soil at site D had been exposed to many more salting seasons. At both locations, the chloride and sodium levels in the spring of 1975, were highest near the road; but the levels after only two salting seasons (site E) were much lower than the levels after many seasons (site D). Also, the area of elevated levels did not extend as far from the road (less than five meters) at site E.

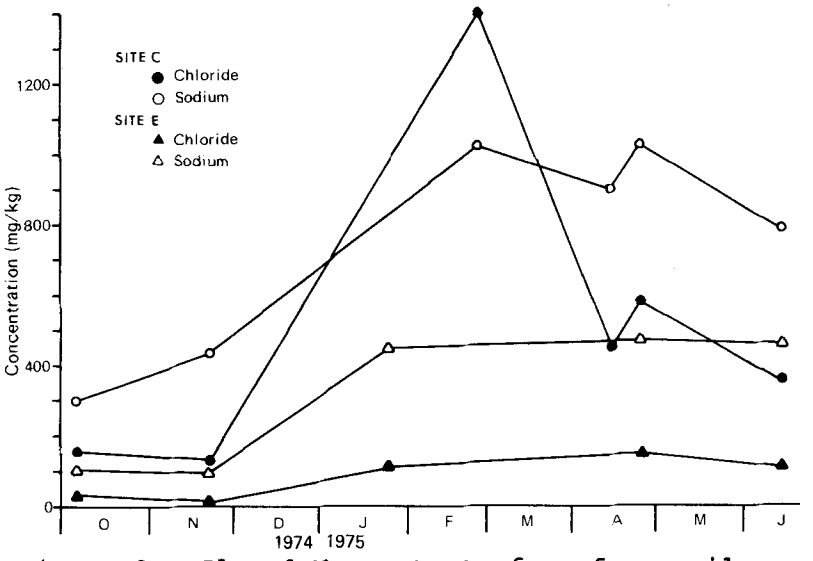

Figure 3. Cl and Na content of surface soils, 0.5 m from pavement, near Don River

With the exception of site D, both chloride and sodium content in the soil increased from autumn 1974 to spring 1975, and sodium content was higher than chloride content (Figures 3 to 5). Due to the frozen soils during the winter period, and the difficulty of obtaining samples, there is a lack of soils data for this period. Limited data collected in January and February (Figure 3), suggest that the soil salt concentrations may fluctuate to very high levels during this period. Samples of the top 5 cm of soil collected on January 26, 1975 from a location adjacent to Dufferin Street, south of Finch, contained 2,025 mg/kg chloride and 1,935 mg/kg sodium. In addition, a sample of sand that had accumulated on the paved median strip of Highway 7 near Dufferin Street was sampled on February 8, 1975, and found to contain 10,800 mg/kg chloride and 7,047 mg/kg sodium.

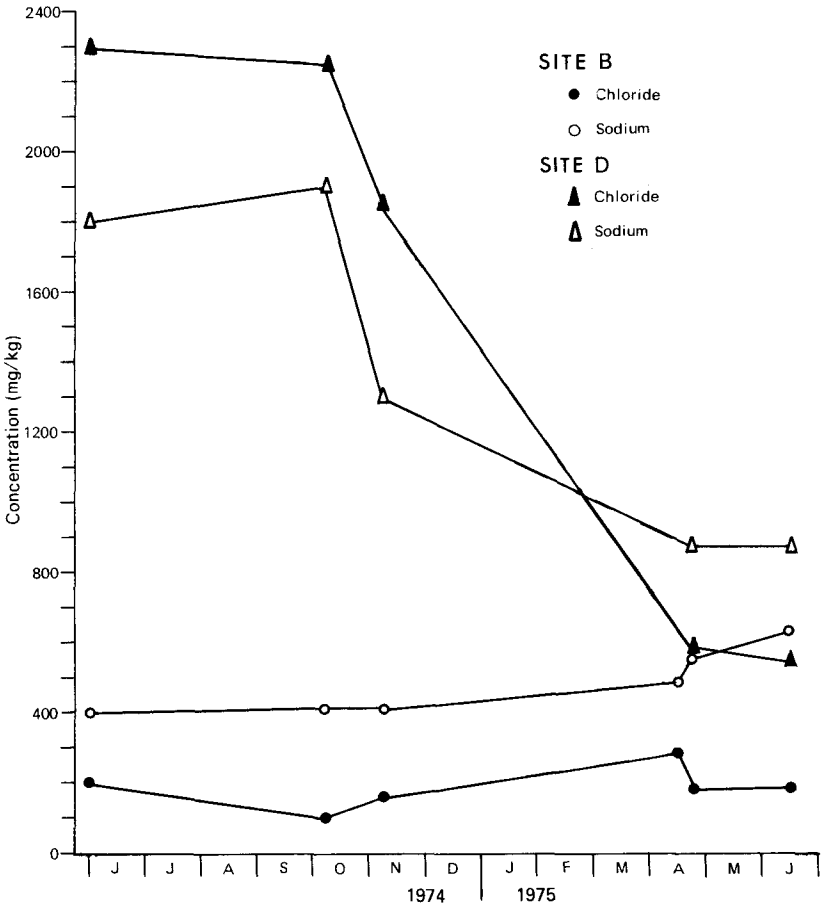

Figure 4. Cl and Na content of surface soils, 1.0 m from pavement, near Black Creek

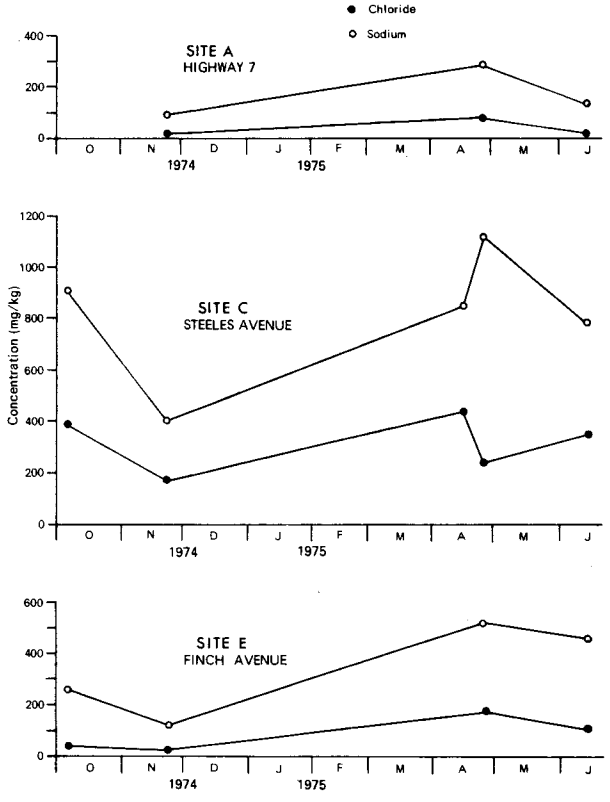

Figure 5. Cl and Na content of surface soils, 1.0 m from pavement near Don River

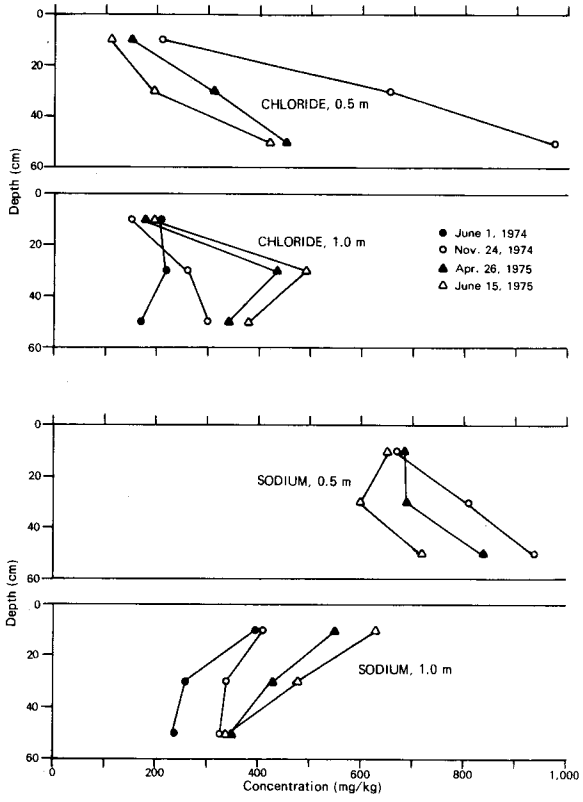

Figure 6. Variation in Cl and Na content with depth at two distances from Steeles Ave. at Site B

The variation in chloride and sodium contents with depth displayed different patterns at different locations (Figure 6). However, at all locations, sodium contents were generally higher than those of chloride. Both sodium and chloride were leached downward, but a greater proportion of sodium remained in the top 20 cm of soil. The two ions move differently through the soil because sodium (a cation) is attracted to and adsorbed by the soil colloids, whereas chloride (an anion) is leached more readily through the soil profile. The rate at which downward movement occurs at a given location is a function of factors such as cation exchange capacity and soil texture.

The chloride and sodium contents of the stream bank samples were higher than the levels found in the control soils, which indicates that some exchange of ions may occur between the stream solution and the stream banks. The data generally show a lack of pattern downstream from salt input points, with the exception of site 4 on the Don River (Figure 7). Concentrations in the banks were

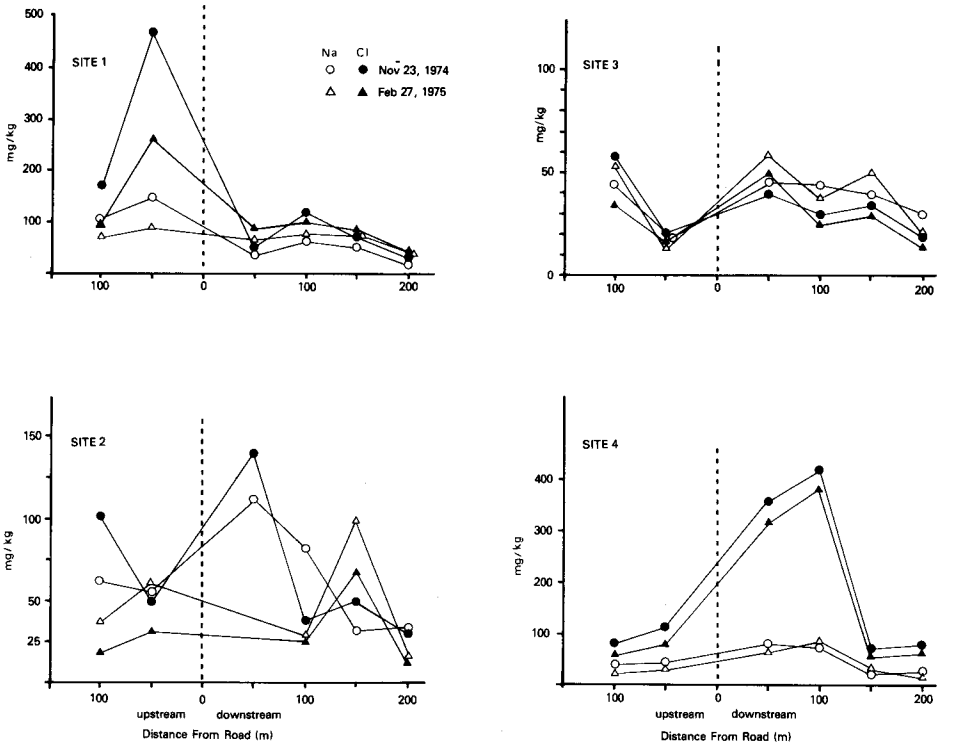

Figure 7. Variation in Na and Cl content of stream bank samples in Black Creek and the Don River

generally lower on February 27 (just after an extensive thaw period) than on November 23. Data indicate that high levels of salt were present in the streams at the start of the thaw (SCOTT 1980), but by the time the water levels began to recede so that bank samples could be collected, some of the bank may have eroded, exposing fresh soil with lower chloride and sodium content. Because of the limited data, however, this possibility cannot be verified.

In conclusion, at the locations where roadside soils were sampled, de-icing salts appear to be entering the soil and increasing both chloride and sodium levels for distances of approximately fifteen meters on either side of the pavement. Levels are highest in early spring but decrease with time as the ions are gradually leached deeper into the soil profile. A portion of the salt present in the spring may not be leached away by autumn. As a result, the levels of chloride and particularly of sodium tend to increase from year to year; however, it appears that levels in the soil in June, 1975 were not as high as in June, 1974.

Some exchange of ions must occur between the stream solution and the stream banks because the chloride and sodium contents of the stream bank samples were higher than the "normal" levels found in the soils of the area. Unfortunately, the extent of exchange between stream bank and stream solution could not be determined within the framework of the present study. The author would like to acknowledge the assistance of A.R. Hill for his helpful suggestions.

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