CHAPTER 4 – CHLORIDE

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Why would we be concerned about chloride in Muskoka waters? Chloride is most frequently encountered when it is applied as road salt to our roads in the winter to clear ice and snow quickly. Salt is simply sodium and chloride bonded together. What we may not be aware of is that in 1999 Environment Canada (Canadian Environmental Protection Act, 1999) declared road salt to be a substance which is toxic and dangerous to even physical aspects of the environment[1]. This declaration was accompanied by recommendations on how its use could be reduced but did not require any specific management responses.

We are all familiar with the bleaching of pine trees along our highways from the salt spray that is generated when traffic goes by. And we're all aware of the effects of salt on our shoes, our cars, and the paws of our dogs when they walk through salt in the wintertime. What we may be less aware of, however, is that this salt moves into the aquatic environment very readily.

Chloride is what is known as a conservative ion in that it does not react with other ions in the environment. As a result, it moves through soil in runoff water and is not taken up in significant amounts by vegetation. What runs off our roads, parking lots, and driveways will ultimately end up in the natural environment and that is frequently in our waters in Muskoka. Sodium in drinking water is also a problem for people that have heart issues and so we do have to watch that, although our lakes are well within safe levels.

Chloride itself is an issue because it is toxic to aquatic life. One of the results of road salt's declaration as a toxic substance was that the Canadian Council of Ministers of the Environment (CCME) developed a water quality guideline for chloride in freshwater (CCME, 2011). They

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[1] *"a substance is toxic if it is entering or may enter the environment in a quantity or concentration or under conditions that (a) have or may have an immediate or long-term harmful effect on the environment or its biological diversity…"*

reviewed all the research on the toxicity of chloride and concluded that, if concentrations were below 120 milligrams per litre (or parts per million, ppm), that there was no significant threat to aquatic life. If that were the case, then we would not be worrying about road salt and chloride in Muskoka. The CCME work was based on studies of chloride toxicity to 30 vertebrate, invertebrate, and algal species was based on studies of chloride toxicity that were conducted in a wide variety of waters. Many of them are representative of waters located off the Canadian shield. These lakes have higher hardness and calcium content than lakes in Muskoka.

Calcium is an ion that helps aquatic life resist the effects of pollutants such as chloride. If there is lower calcium in our water, then things like chloride are more toxic. Research that has been done since 2011 (Arnott et al., 2020) shows that chloride concentrations as low as 10 or 20 milligrams per litre (parts per million) in low-calcium waters can damage sensitive aquatic life, particularly zooplankton. Thus, the low calcium waters of Muskoka make the aquatic life in our lakes particularly sensitive to chloride. As a result, in Muskoka we consider chloride concentrations above 10 ppm as potentially harmful to sensitive aquatic life. We note that many Muskoka waters have less than 1 ppm. These are lakes where there are no roads to add road salt and the concentrations are considered *baseline* or unaltered.

We are concerned that chloride coming into our low calcium waters from road salt applications is potentially harmful to aquatic life at current levels. We will present data on current chloride levels in our lakes, how they've changed from baseline conditions, how they have changed from our 2018 Report Card, and whether they pose a risk to aquatic life.

DATA SOURCES

Our analysis relies on water quality data that has been collected by the District Municipality of Muskoka (DMM) as part of their Lake System Health program. DMM samples approximately 90 lakes every year and repeats those measurements every second year for a total of approximately 200 lakes in their database. The lakes are sampled in May and early June. At this time, they have not yet stratified and so water quality is similar from the surface to the bottom, such that a grab sample taken from the surface provides a good representation of the chloride level throughout the lake. DMM sends the water samples to the Ministry of Environment Conservation and Parks (MECP) for analysis to strict laboratory standards and the Ministry provides the data back to DMM. The Report Card also uses data from the Lake Partner Program (LPP) of the Ontario MECP. These data are collected by citizen scientists (volunteers who collect samples) according to MECP protocols at generally the same time of the year as DMM and send the samples to MECP labs for analysis. As a result, this version of our watershed report card reports on chloride concentrations from 274 lakes or lake segments with records for some extending back to 2004: an enviable database.

HOW ARE WE INTERPRETING OUR CHLORIDE DATA?

We are relying on two basic metrics for presenting and interpreting the chloride data. One is the current chloride concentration based on samples taken between 2018 (the last report card) and 2022. If there were fewer than three samples in that time, we included samples from 2017 to keep our sample size to a minimum of 3 recent measurements.

- We classified the number of lakes that were: less than 1 ppm (considered to be unaltered) and between 1 and 10 ppm where 10 ppm is considered the threshold for potential damage to sensitive aquatic life. We also counted the number of lakes where concentrations exceeded 20 ppm for (lakes considered more seriously threatened) and have highlighted several lakes where the concentrations are very high.
- The second metric we used asked the question: Which lakes are increasing or decreasing in chloride? For this we had to recognize that not every lake has data going back long enough to get a good sample of this but, in general, for each lake, we took every measurement that was in our database, averaged them, and compared that to the average concentration measured over the last five years. An average of the most recent five years which was 0.5 mg/L higher than the historical record was indicative of increasing chloride concentrations and a recent average 0.5 mg/L lower indicated decreasing concentrations.

In some cases, low sample sizes (1 or 2 measurements) confounded our interpretation. Another concern was that some Muskoka lakes are not located on the Canadian shield. Southern parts of Muskoka such as the Severn River drainage and parts of the Georgian Bay drainage are in fact in areas where the bedrock and soils contain more calcium (“calcareous soils”). In these areas the natural levels of calcium and chloride would be higher independent of road salt application. In those cases, examination for any increasing trends and comparison of calcium and chloride levels was used to interpret any role of road salt in higher chloride levels.

RESULTS

Chloride data were available for 274 lakes or lake segments (e.g. several bays within one lake) and results for each lake are presented in Table 12. Chloride concentrations were <1 mg/L and thus considered unaltered in 80 of 274 (29%) of the lakes. Concentrations ranged from 1.0 - 9.99 mg/L in 127 (46%) of lakes. Concentrations exceeding 10 mg/L and considered potentially harmful were recorded in 67 lakes (24%) and in 36 of these, exceeded 20 mg/L. In eight lakes, six located in the South Georgian Bay Shoreline and two in the Sparrow Lake watersheds, enriched chloride concentrations could be attributed to natural sources, the influence of calcareous, off-shield drainage.

Table 12. Chloride in 274 lakes in Muskoka 2018-2022.

	n=	< 1.0 mg/L	1.0 – 9.99 mg/L	10 – 20 mg/L	> 20 mg/L
Number of lakes	274	80	127	31	36
Percent of lakes		29%	46%	11%	13%

The distribution of Cl concentrations across all lakes is shown in Figure 9. Concentrations exceeding 60 mg/L were recorded in;

- Burnt Lake (76.2 mg/L), adjacent to Hwy. 400;
- Roberts Lake (72.1 mg/L), adjacent to Hwy. 69 and Hwy. 400; and
- Jevins Lake (113 mg/L), downstream of Hwy. 11 and the south Gravenhurst commercial area.

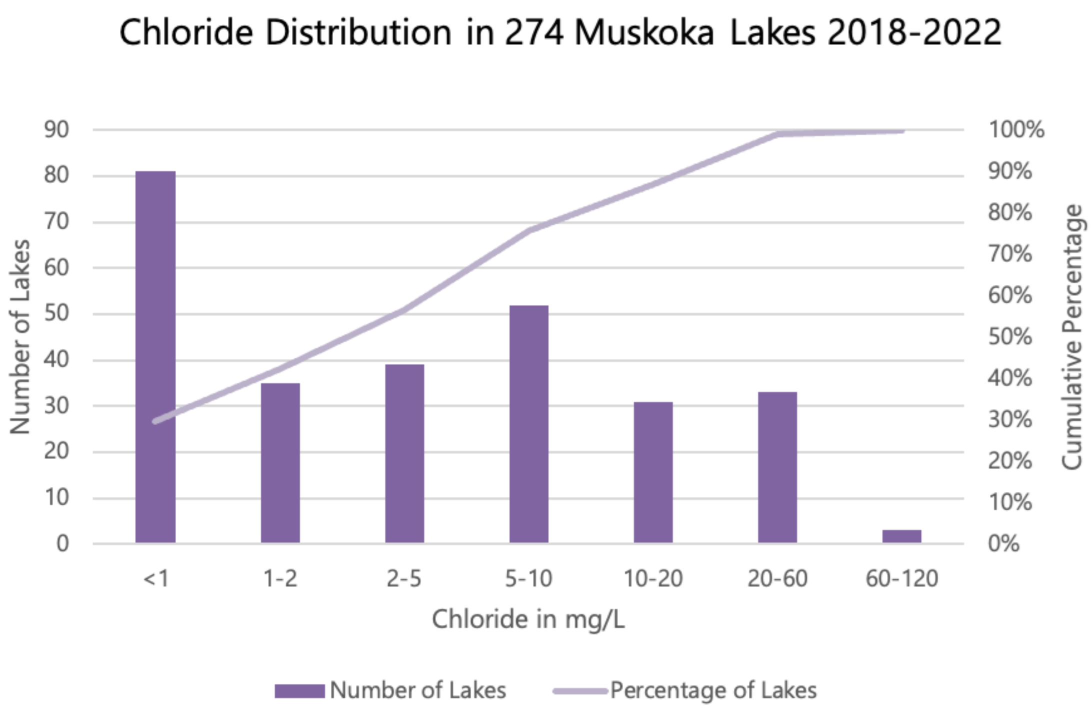

Figure 9. Chloride distribution across all sampled lakes.

Chloride concentrations had increased by more than 0.5 mg/L in 80 of 274 (29%) of the study lakes and had decreased by more than 0.5 mg/L in 13 (5%) lakes (Table 13, Figure 10). The increases exceeded 10 mg/L in Jevins Lake, which receives urban drainage from Hwy. 11 and the commercial area of southern Gravenhurst, and in Cornall Lake which is downstream of Jevins Lake. Increases exceeded 2 mg/L in five of the eight lakes that were "off-shield" indicating that, even in areas of calcareous bedrock and higher natural chloride concentrations, road salt contributed to the elevated chloride concentrations. Although chloride concentrations decreased in 13 lakes the reasons are unknown and likely relate to small sample sizes in which the influence of one year may be over-stated. Further monitoring is recommended.

Table 13. Changes in Chloride Concentration: 2018-2022 vs Historic Record.

	n=	+> 0.5	-> 0.5
Number of lakes	274	80	13
Percent of lakes		29%	5%

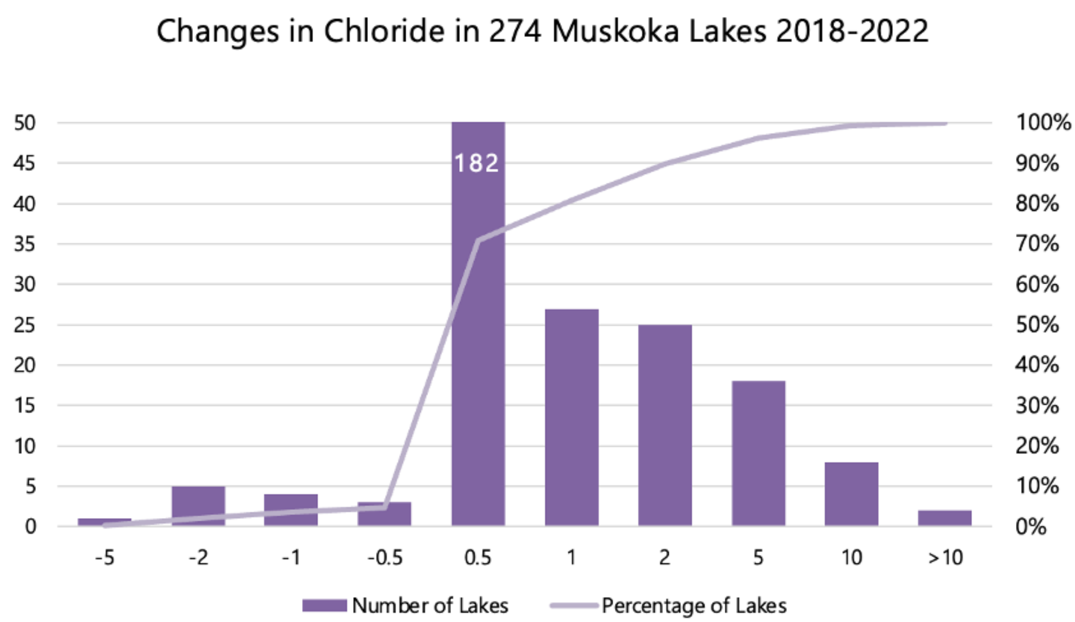

Figure 10. Changes in chloride concentration: 2018-2022 vs All Years.

Jevins Lake (Figure 11) reported the highest chloride concentration and the greatest increase of all the lakes included in the Report Card. The lake receives runoff from the commercial areas at the south end of Gravenhurst and from Highway 11. Figure 11 also shows the record of chloride increasing in Muskoka Bay, an iconic centrepiece of our Muskoka waters. The bay receives runoff from the urban and commercial areas of Gravenhurst and from Hwy 169.

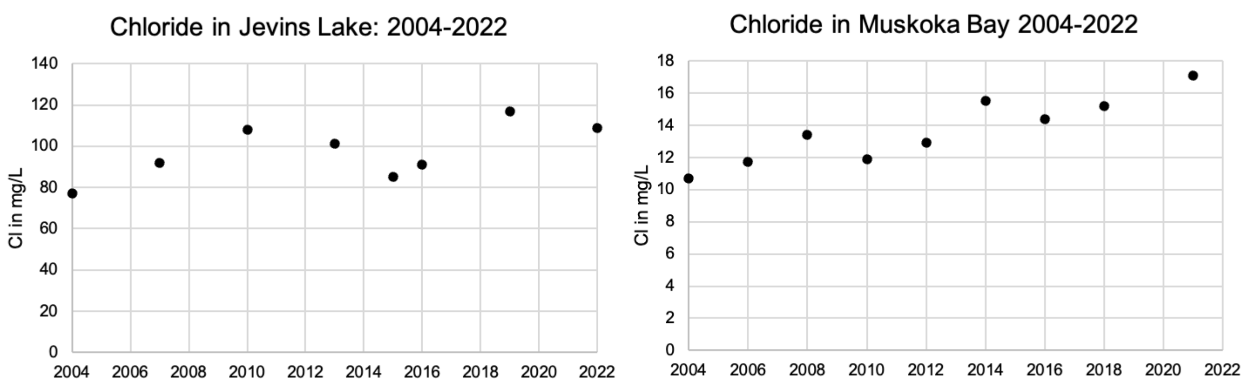

Figure 11. Chloride in Jevins Lake and Muskoka Bay.

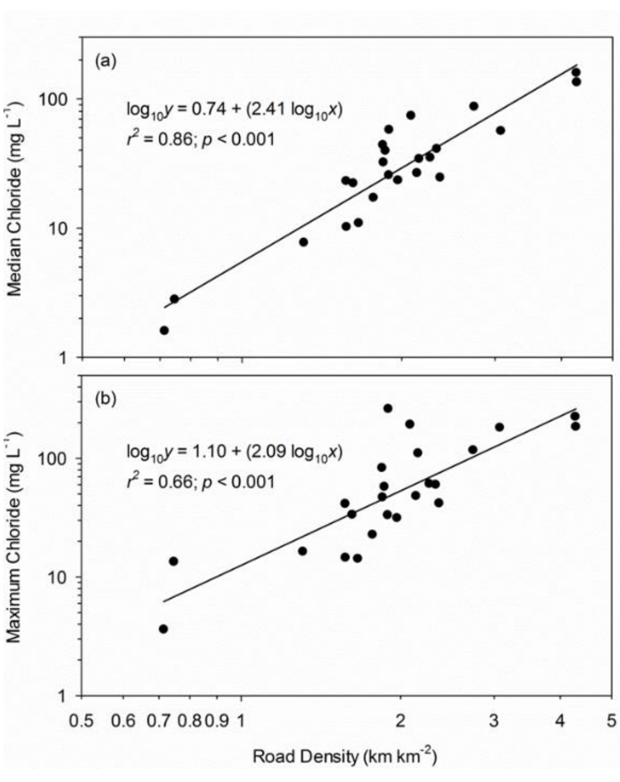

Figure 12. Road density and chloride in southern Ontario streams (from Todd & Kaltenecker, 2012).

Todd & Kaltenecker (2012) reported that road density is related to chloride concentrations in streams in heavily populated areas of southern Ontario (Figure 12). While mean chloride concentration showed no relationship with road density in the 18 Muskoka quaternary watersheds contained in our dataset there was a significant ($p<0.015$) relationship between road density and the percentage of lakes in a quaternary watershed in which chloride had increased in 2018-2022. (Figure 13). The use of average values for road density and chloride in each watershed, however, provides a very coarse analysis and further investigation using lake-specific measures of road density would provide a more accurate metric. Lake-specific estimates of road density are not available.

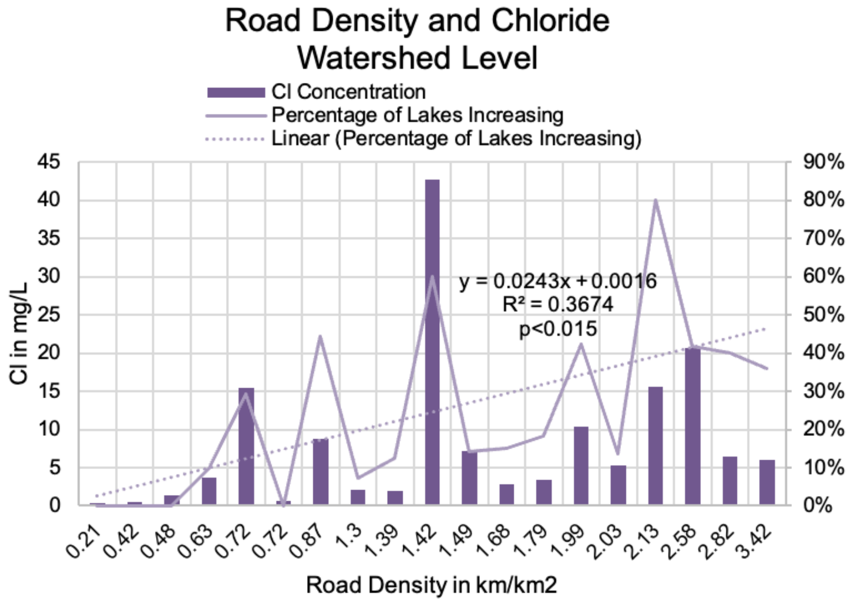

Figure 13. Road density and chloride in 18 Muskoka watersheds.

WHAT DOES IT ALL MEAN?

Road salt use has generated substantial increases in the concentrations of chloride, a toxic pollutant, in Muskoka's lakes. Chloride concentrations exceeded 1 mg/L and were therefore considered enriched in 193 of 274 (70%) lakes. Concentrations exceeded 10 mg/L and so were considered potentially harmful in 68 lakes (25%). In 36 of these, chloride concentrations exceeded 20 mg/L. The average chloride concentrations measured in 81 (29%) lakes have increased in the past five years, exceed 70 mg/L in three lakes and exceed 115 mg/L in Jevins Lake. Further investigation at a lake-specific level is required to determine the role of road density on chloride in Muskoka lakes.

While management actions are warranted to halt and reverse the increasing chloride in our lakes, the 2001 Environment Canada assessment report cautioned that *"Any measures developed as a result of this assessment must never compromise human safety; selection of options must be based on optimization of winter road maintenance practices so as not to jeopardize road safety, while minimizing the potential for harm to the environment…".* MWC should therefore support existing initiatives to monitor and document road salt sources and work with provincial and municipal governments and the public to reduce and optimize road salt application in Muskoka by government, businesses, and individuals.