THE TRACING OF SALINITY IN THE LEHIGH RIVER AND ITS EFFECT ON RIVER SPECIES

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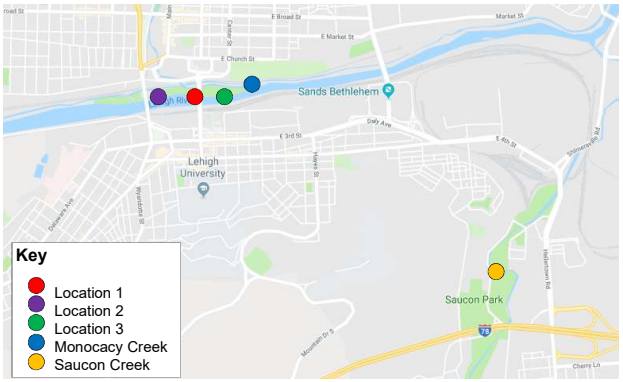
Introduction

The overall questions originally asked were: **how greatly does salt concentrated runoff due to road salting affect the salinity of the Lehigh River? Are these levels of salt harmful to the flora and fauna, such as amphibians and macroinvertebrates, of the river?** Every winter the city of Bethlehem uses copious amounts of salt to melt snow and keep the roads clear. In the 2016-2017 winter alone, Bethlehem and Lehigh University used a combined amount of 5,854 tons of rock salt (PennDOT, 2018). This leaches into rainwater which then runs into the Lehigh River and surrounding tributaries, potentially disrupting the river ecosystem. This study was directed at seeing whether the large abundances of salt used this passed winter (2018) had caused the salt concentration of the Lehigh River to rise above toxic levels for certain keystone and indicator species, i.e. large fish, macroinvertebrates, etc.

Sampling Locations



Google Maps, 2018

For this study, five different locations were sampled over the course of 10 weeks from February 24th 2018 to May 5th 2018. Samples were collected every two weeks as well as after the melting of snowfall in order to measure the road salt that had runoff into the river from the snow events. Three locations were picked in the Lehigh River, Location 2 being directly across the river from a storm drain. A sample was taken from both the Monocacy and Saucon Creeks, for the purpose of measuring their salt input into the Lehigh River.

Instrumentation

An Ion Chromatograph (IC) was used to conduct the measurements. Chloride anions were measured in the samples collected from the Lehigh River and other creeks because chlorine is the major component in any road salt.

Bethlehem and Lehigh University primarily use rock salt (NaCl) to keep roads from freezing (PennDOT, 2018).

Thermo Fisher, 2018

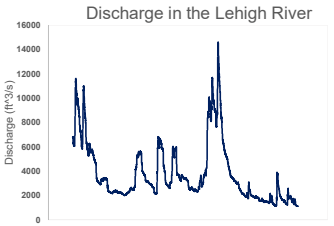
Methods

Along with the samples taken over the 10 week period, a rainwater sample was collected to track the effects of chloride. Another sampling took place on July 10th 2018 to measure summer salinity conditions months after the last road salting.

All of these samples were filtered through 0.2 µm supor membrane syringe tip filters and then transferred to IC vials to prepare for analysis. The samples were run through the IC, measuring Cl anion concentration in µmol/kg.

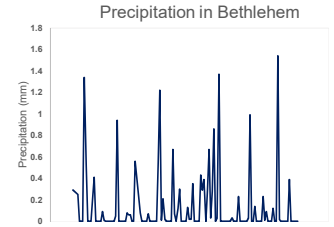
Sulfate anions were also measured to track the effects of chloride on the salinity of the river and creeks, using a sulfate/chloride ratio.

Results



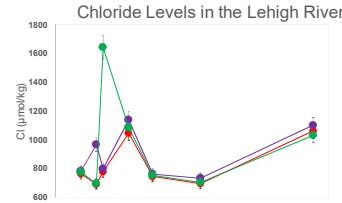
The discharge from the Lehigh River is rarely stable due to precipitation (USGS, 2018).

The larger the discharge in the river, the lower the chloride concentration, as seen from mid-April to mid-May.



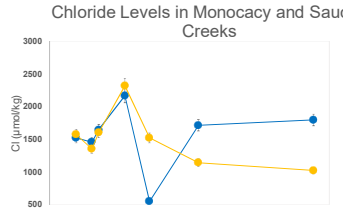
Precipitation affects the discharge of the river and therefore the chloride concentration of the river (NCDC, 2018).

However, there appears to be no direct correlation between precipitation and chloride concentration.
The rainwater sample had a 10.47 µmol/kg chloride concentration.



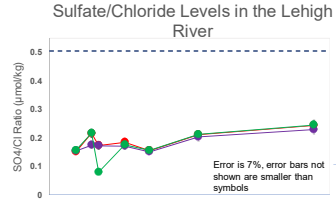
Cl concentration spiked in late March, which was after 3 large snowstorms this year. Location 3 specifically more than doubled in chloride concentration as it was further down stream than the other locations.

In April, the Cl dropped again and surprisingly started again rising in early summer.

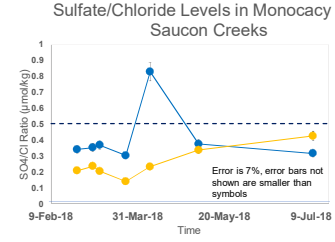


Both creeks spike significantly around the same time as the river, however they rise in Cl almost double the amount of the river's highest value.

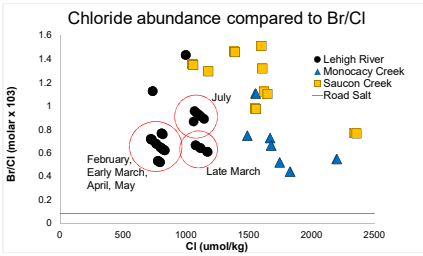
After the spike, Saucon lowered in Cl gradually, while Monocacy steeply dropped. This is due to the creeks meeting with the Lehigh River and diluting in Cl as a result. Plants will also take in Cl when absorbing water.



Both the Lehigh River and the creeks keep around the same SO4/Cl ratio over the sampling period. The SO4/Cl ratios of the Lehigh River and the creeks are, for the most part, below that of rainwater and above that of road salt.



However, there is a steep spike in the ratio in Monocacy Creek in late March. This indicates that there is not much Cl input from salt, and that Cl and SO4 co-vary, perhaps due to higher evaporation or rainfall at certain times of year.



Notice the clumping of three groups of data in the Lehigh River. These groups are of certain dates which samples were taken (see graph). The groups closest to the Road Salt line have a higher abundance of Cl that may be road salt derived as made evident by the Br/Cl ratio. Monocacy Creek has the highest Cl of all the rivers and streams due to its gathering of runoff from North Bethlehem.

Wood Frog, VHS

	Toxic Chloride Level (µmol/kg)
Rainbow Trout	598904.9
Largemouth Bass	205538.8
Stonefly Eggs	9034.9
Caddisfly Eggs	142299.8
Water Flea	51334.7
Wood Frogs	5646.8
Average of Freshwater Species	7052.2

In the chart above, there are the chloride toxicity levels of six animal species found in the Lehigh River. Most of the species have toxicity levels that are much greater than the maximum chloride concentrations found in the Lehigh River, Monocacy, and Saucon Creeks. Saucon and Monocacy Creeks reached their highest chloride concentrations of 2316 and 2166 µmol/kg respectively in late March 2018 and were closest to the toxicity level of the common wood frog, of about 5646.8 µmol/kg. Plants may be affected differently by salinity and, although they were not considered in this study, they could be a course of further study into the effects of road salting on the Lehigh River ecosystem.

Conclusions

In conclusion, the highest chloride concentration observed in the Lehigh River and its tributaries in winter 2018 did not exceed chloride toxicity levels for fauna. At their highest chloride concentrations, Saucon and Monocacy Creeks were the closest at reaching the toxicity level of the wood frog. **While the wood frog's toxicity level is still two times that of the creeks' maximum chloride concentration it is important to note that with increasing global temperatures, snowfall is also expected to increase. In fact, within the upcoming years snowfall is predicted to increase if climate change continues at its current rate (Burnett, 2003). If snowfall doubles, greater amounts of road salt will be used, causing the chloride concentration in the Lehigh River and other creeks to increase. The water may then rise to toxic chloride levels that will lower the wood frog population, along with other amphibians.** Still, the wood frog population is being affected by road salting. With high salinity levels, a wood frog egg will produce a male tadpole. Wood frogs lay their eggs in pools near roads and river banks in early spring. These pools tend to become overconcentrated with road salt which changes the gender of all the tadpoles in these pools to male (Lambert et al, 2016). With a population overrun with males, the wood frog is unable to reproduce as readily and its population will decline significantly. In addition, a 2010 study by the USGS did notice a decrease in the common water flea in the Lehigh River after a winter with heavy snowfall. Water fleas are a large source of food for fish such as trout and a decrease in the flea population could lead to a decrease in certain fish species. This study could be critiqued as inaccurate, but also shows that other factors could be affected the water flea population.

Acknowledgements

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