Ammonia Emission Potentials for Arctic Soils

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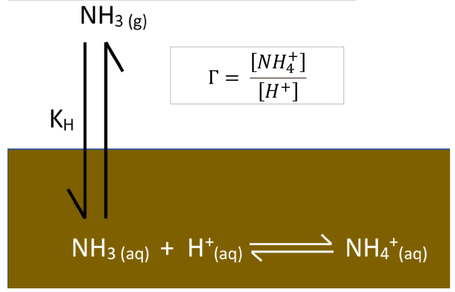
Introduction

- NH_3 is the most prevalent basic gas in the atmosphere.[1]
- Can neutralize H_2SO_4 particles and stabilize them, which can affect air quality.[1]
- Tropospheric particles can impact radiative forcing by inducing a cooling effect, which can impact climate change by counteracting the radiative forcing of greenhouse gases.[2]
- Seabird colonies are likely to be an important source of ammonia in the summertime Arctic.[3]

Importance of soils as a source of ammonia in the Arctic region

Compensation Point:

$$\chi = 13587 \times \Gamma \times e^{\frac{-10396K}{T}} \times 10^9$$



$$\Gamma = \frac{[NH_4^+]}{[H^+]}$$

Figure 1: Schematic of soil-atmosphere bi-directional exchange

- Compensation point is the equilibrium concentration of $NH_{3\,(g)}$ based on the pH and ammonium content of the soil.
- Equation for χ is derived from the van't Hoff equation.
- If ambient $NH_3 > \chi$, deposition occurs, and if $NH_3 < \chi$, emission occurs.

Methods

- Soil data were obtained from existing literature and the Arctic Data Centre repository.[4-7] Temperature data were obtained from the Government of Canada website. Ambient ammonia data was collected in 2015 by Murphy group members.
- Variables of interest were soil ammonium content, pH, and moisture content, which were then used to calculate emission potential of ammonia.
- In the calculation, the ratio of NH_4^+ to H^+ was determined per dry weight of soil (mol/kg dry soil).
- Molarity ratios could not be used since the pH of added liquid for soil slurries was not known.

Results

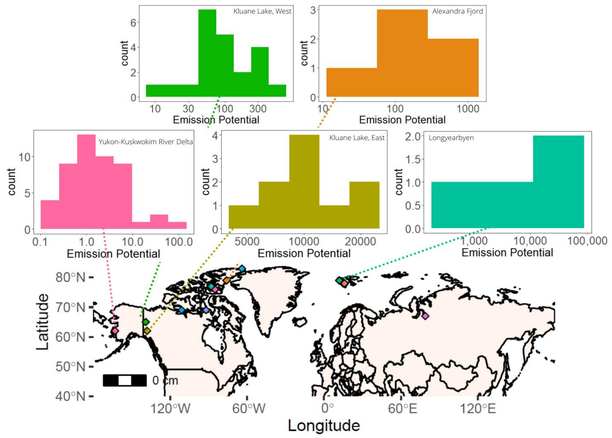


Figure 3: Map of sites with histograms of emission potential

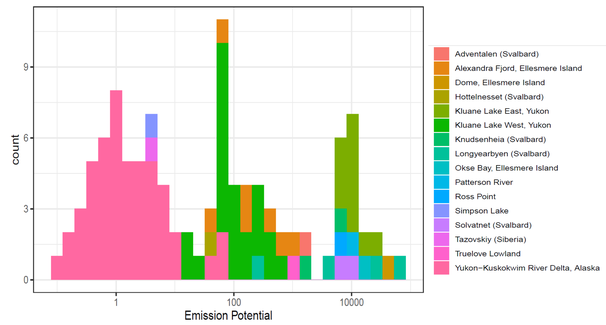


Figure 2: Histogram of all emission potentials

- Even at one site, emission potential ranges over more than one magnitude.
- The lowest value was less than 1 while the highest was over 1000 units among all sites studied.

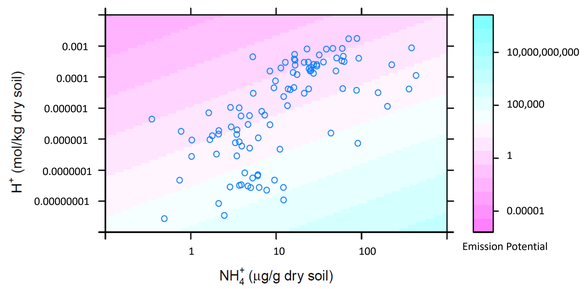


Figure 4: Gradient plot of NH_4^+ with H^+ with data points

- For a given site, emission potential can be estimated if NH_4^+ and H^+ are known. To use pH, one requires the moisture content range to obtain an estimate of possible emission potential values.

Results

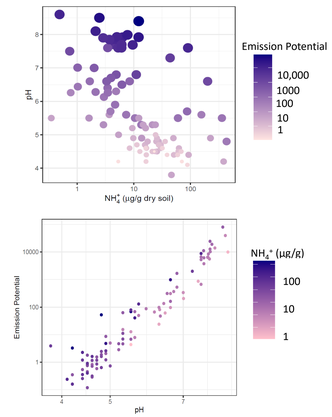


Figure 5: NH_4^+ and pH with emission potential scatterplots

- pH varies more than NH_4^+ for the Arctic sites found.
- As pH increases, the range of NH_4^+ values is limited.

Figure 6: Compensation point at Patterson River in 2009

- Compensation point is highest in summer, when temperatures are highest.

Figure 7: Compensation points and ambient ammonia at ALERT, Nunavut in 2016

- Ambient NH_3 was lower than calculated compensation points.
- Data is from the summer of 2016 at the ALERT site, which is close to Patterson River.

Discussion

- pH varies more than NH4+ in Arctic soils, thus leading to more variation in emission potential.
- At a given site, emission potentials can vary over large magnitudes, which is likely due to varying soil characteristics.
- It is difficult to determine a single emission potential value to describe the Arctic.
- At ALERT/ Patterson River, the soil appears to be a source of ammonia since ambient ammonia is less than the compensation point.
- Sources of error may include the assumption that emission potential is constant throughout the year as well as for different years (in Figure 7); this is a limitation of the data.
- Another source of error is the fact that air temperatures were used for compensation point calculation, as opposed to ground surface temperature.
- Future studies could look at the impact of different microbial communities on ammonium in Arctic soils. This study could also be part of a larger one on ammonium cycling in the Arctic in general.

Acknowledgements

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Arctic Data Centre: https://arcticdata.io/catalog

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