Zinc deposition in epiphytic bioaccumulators in downtown Portland, OR in areas of tear gas munitions detonation

Evelyn Haase, Danielle Cass | Reed College Chemistry Department

Tear Gas Munitions in Portland, OR

Protests over the summer of 2020 in support of the Black Lives Matter movement saw a dramatic increase in the use Riot Control Agents (RCAs) namely tear gas in response to protestors. Tear gas munitions contain heavy metals, notably zinc (Zn) as a smoke screen agent.

Detonated tear gas munition (photo: CWRC)

Epiphytes as Environmental Sensors

- Historically, lichens and mosses have been used to assess environmental quality, particularly heavy metal deposition. Lichens and mosses are known bioaccumulators and therefore bioindicators. (Bozkurt, 2017)
- Air pollution negatively impacts the frequency and density of lichens in urban areas. Studies suggest mosses are less sensitive to variation in air quality than lichens.

What is the impact of tear gas munitions detonation on the concentration of zinc metal in epiphytes, which are known bioaccumulators?

Methods

Select 4x4 block region of downtown Portland, OR heavily impacted by tear gas munitions use adjacent to regions with no tear gas munitions use.

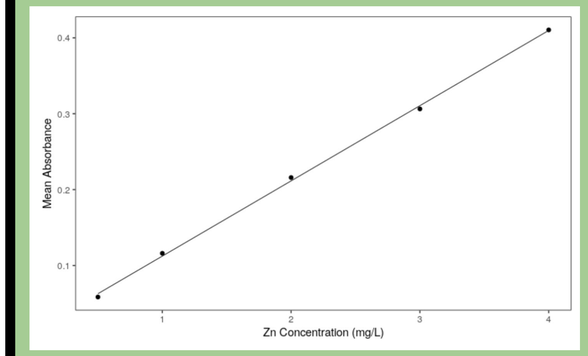
Collect *Parmelia* lichens and *Polytrichales* mosses from street trees at a height minimum of 1.5m using a teflon coated razor blade.

Rinse, dehydrate, and powderize samples in preparation for nitric acid based digestion.

Analyze samples using flame atomic absorption spectroscopy (FAAS) to quantitate the concentrations of Zn.

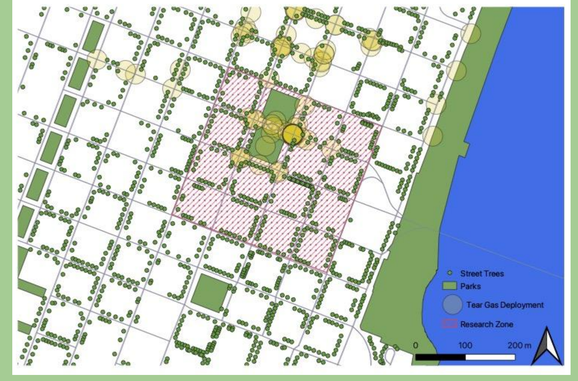
Digestions and Collections

- A standard curve for Zn between 0.5 - 4.0 ppm was run on the FAAS to prepare for epiphyte samples.
- NIST soil samples were used to gauge efficacy of the acid digestion methods.
- Two digestion methods used: water bath digestions at 95C and microwave digestions at 140C



Results (left) of a 5 concentration (0.5, 1.0, 2.0, 3.0, 4.0 ppm) standard curve using flame atomic absorption spectroscopy. The linear relationship between Zn concentration in mg/L and mean absorbance can be modeled by the equation $y = 0.099089x + 0.013353$. The line of best fit has an R^2 value of 0.9991.

Research zone for epiphyte collection for zinc bioaccumulation analysis, July 2021



Map (left) created by Evelyn Haase mapping sites for sample collection in Portland, OR with reference to a dataset prepared by PSU with locations of tear gas munitions detonations during the Portland protests in the summer of 2020. Epiphyte sampling zone and green street trees are overlaid by a red hatched region.

- 310 epiphyte samples were collected from 267 street trees.
- 19 samples were successfully digested via water bath method and 119 were digested using a microwave digestion method
- Samples were collected from varying tree species and tree ages over the course of 2 weeks in July, 2021

Findings and Observations

Lichen sample in 20 mL glass vial.

Lichen samples dehydrating in an 80°C oven for 48 hours. Samples are cooled in a dessicator.

- Epiphytes in the field differed in density between street trees based on sunlight, tree type, and tree age.
- *Parmelia* lichens and *Polytrichales* mosses (commonly shield lichens and hair moss) are most common in downtown Portland, OR due to their high resilience to air pollution.
- There is no significant difference in Zn uptake between mosses and lichens, both epiphytes prove effective bioaccumulators.
- Trees in regions where tear gas was used showed no significant difference in epiphytic zinc concentrations

Future Steps

- Analysis of samples using ICP-OES or ICP-MS
- Interpolated mapping of metal concentration results

Applications of Methods

- Epiphytic bioaccumulators can be used as environmental sensors to quantify the concentrations of various metals depositions in city zones.

Acknowledgments

Thank you to the Moore Foundation Fellowship for funding, Danielle Cass for guiding this research, and Tess Rutstein for monumental help in field work and sample preparation. Additional thanks to Henry Holleb for lab work assistance.

Literature Cited

1. S, C.; N, D.; G, D.; D, G. Exposure to Atmospheric Metals Using Moss Bio-Indicators and Neonatal Health Outcomes in Portland, Oregon: Environmental Epidemiology 2019, 3, 79–80.
2. Chemical Weapons Research Consortium
3. Fenn, M. E.; Geiser, L.; Bachman, R.; Blubaugh, T. J.; Bytnerowicz, A. Atmospheric Deposition Inputs and Effects on Lichen Chemistry and Indicator Species in the Columbia River Gorge, USA. Environmental Pollution 2007, 146 (1), 77–91.