The Influence of Urban Air Pollution on the Chemical Composition of Run-off from Seasonal Snow Meltwater in the North Shore Mountains of Vancouver.

** Research Proposal **

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Abstract

'Acid Snow' and chemically altered precipitation has been identified in both seasonal and permanent snowpacks, even in locations far from pollution sources. The modification of the resultant supply to springtime meltwater has the potential to alter downstream ecosystems, wildlife habitats, and groundwater supplies. This study will look at the influence of anthropogenic air pollution on the chemical composition and the acidity of a near-urban snowpack, in one of Canada's most populous cities.

This project will aim to measure the level of contaminants in samples of freshly fallen snow, while keeping track of air pollution levels using Metro Vancouver's already established network of monitoring stations. Samples will also be collected from the seasonal snowpack throughout the winter at regular time intervals, by the way of snow cores. A semi-permanent sampling location will be identified and used throughout the course of two winter seasons. Sampling tools and processes will be similar to how avalanche forecasters capture snow samples from storm events, along with a portable field kit for chemically analyzing the samples. Motivation for this study is drawn from the fact that an investigative project evaluating the physical concentrations of pollutants in seasonal snow and springtime runoff, could allow ecologists to better model habitat inputs of contaminants, and give the scientific community a greater understanding in the life-cycle of chemicals that originate from anthropogenic sources.

Introduction

Studies performed during the 1970's and 1980's have shown that both seasonal and permanent snow fields have the ability to absorb atmospheric chemicals, sometimes far from their original source [Davidson et al., 1987, Barrie, 1986, Johannessen et al., 1978, Tranter et al., 1986, Rascher et al., 1987, Mayewski et al., 1987, Galloway et al., 1982].

These studies have shown in Scotland, Greenland, and Norway, that 'acid snow' is a phenomena that even remote ecosystems can suffer from. We must then wonder about the chemical makeup of meltwater that originates from the North Shore mountain seasonal spring runoff, with it being in such proximity to anthropogenic sources of air pollution.

The Metro Vancouver area already has ground-level air pollution monitoring stations, that provide data free of charge via the BC Ministry of Environment website `www.envistaweb.ca`. The only 'mountain' based motioning site is at Whistler mountain, where a relatively expensive data collection set-up is in place. It is proposed that the in-situ urban monitoring stations may be used as the 'source' measurement for pollutant contaminants, and this project is then to examine any possible indications of the North Shore mountains snowpack acting as a 'sink' for these pollutants. This chemical sink scenario is a similar approach taken in Scotland by Tranter [Tranter et al., 1987], and Johannessen et al in Norway [Johannessen and Henriksen, 1978].

Bringing together previous pieces of research and applying it in a local context, research questions this proposed project will aim to address are:

- Is there a correlation between ground level air pollutant concentrations measured in metro Vancouver, and the chemical composition of the North Shore mountain snowpack? That is, can we find evidence of anthropogenic pollutants absorbed in the snow.

  If so:

- Could a model be developed that will assist in forecasting the chemical composition of springtime meltwater using the corresponding Winter's air pollution data?

This study is relevant to the local environment and particular the North Shore mountain watersheds because chemical composition in stream flow runoff has been shown to be affected by anthropogenic pollutant sources in snowpacks in both Scotland and Greenland [Tranter et al., 1986, Mayewski et al., 1987], .

Additionally, the absorption of airborne chemicals and particulates by ground covering snow have been known for many years but recently a team led by Nazarenko at McGill have shown the alteration of chemical compounds while in-situ in a snowpack, and absorption of vehicle exhaust emissions by snow in an urban setting [Nazarenko et al., 2016]. This could be a concern in Vancouver due to the proximity of a large population base so close to snow covered areas.

This research will broaden on previously studies that show seasonal snowpacks exhibiting preferential elution of dissolved compounds [Johannessen and Henriksen, 1978].

Methods

Many methods cultivated from the cited literature will help direct me in formulating ways in which to answer the research questions identified above. Along with these will be field sampling techniques that I have utilized in previous field work and employment (ie. The Avalanche industry). The primary methods are field and observation based, with some numerical analysis of pre-existing pollution data. My anticipated approach will include:

- For the long term look at contaminants in the snowpack over the course of the entire winter, snow-core samples will be taken at a variety (number and locations yet to be verified) of stations throughout the North Shore mountains, with a time scale of approx one sample in each location per week.This snow-coring technique follows from Rascher et al in their research in the Adirondacks [Rascher et al., 1987].
- In regards to analysis of freshly fallen snow, samples will be taken from 'storm boards' which sit on top of the snow and collect snow for as long as the researcher wishes for it to accumulate. This allows a more direct correlation for source-to-sink chemical analysis, and multiple boards allow samples to sit for varying amounts of time which may allow for the 'off gassing' of pollutants to be observed. This sampling technique is similar in fashion to the approach that highway and ski area avalanche forecasters take for snow observations. An example is seen in appendix A, Image 1.
- The sampling locations would need to be independently assessed by a representative of the governing park body, or at least, one of the senior search and rescue officials for the area. A wintertime mountainous sampling objective will require correct planning to avoid potential incidents.
- Care needs to be taken in sampling to reduce contamination by such methods as the polyurethane tubes used by Mayewski et al in Greenland [Mayewski et al., 1987]. Also of consideration is the spatial variability of sampling as prescribed by Tranter et al while studying the spatial trends in Scotland [Tranter et al., 1987].
- All snow samples will then be melted and the resultant water tested for Sulphate, Nitrate, and pH. These field-lab methods are already taught at UBC in GEOB 309, and can be performed with the use of a field kit such as the Chlor*test CSN kit, from Stone Tucker instruments.
- Data analysis will be done via python scripts written for the purpose, with the metro Vancouver air pollution data available online as csv files.

Timeline and Budget

As mentioned, this is a project is expected to take two years (two winter seasons of sampling) ie. MSc research; yet if strong correlations are found, a possible extension would be to develop a model to predict streamflow pH anomalies from the discharge of meltwater runoff during springtime (ie. PhD thesis).

An exact budget is yet to be finalized, but considerations include:

- The budget does depend somewhat on the abilities of the researcher. For myself, the task of traversing the North Shore mountains on skis or snowshoes is somewhat straightforward - but a field technician or assistant should be recruited for safety reasons with the environment and season taken into consideration (ie. A keen undergrad with previous back-country skiing or snowshoeing experience).
- The building of snow study plot can be done 'in-house', and should be in the order of $100 - $150. The snow coring device can be obtained from many scientific instrument sources (as seen in appendix A, Image 2). It is possible that UBC already has one for research purposes, most likely in the Geography department. Costs for a new snow sampler were not available at the time of writing.
- The data of air pollution form metro Vancouver is free of charge.
- Python software is open-source and free of charge. Computing power is not expected to be large; a high quality laptop and a form of reliable memory storage should be sufficient.
- Transport to and from the North Shore mountains will be required.
- Equipment costs (hard goods, chemical sampling kit): $1000.00 CAD
- Transport costs (fuel and maintenance): $500.00 CAD
- Misc costs (poster & document etc): $500.00 CAD
- Total Costs: $2000.00 CAD

Implications

Foreseeable implications of this research include allowing biologists and hydrologist to understand the sources of chemical components of North Shore mountain runoff.

This research would allow policy makers to understand what kind of effects anthropogenic air pollution has on the surrounding environment other than the medical concerns and crop damage already accepted.

From an atmospheric science perspective, this research could allow for a greater understanding in the life-cycle of atmospheric chemicals and pollutants, and whether we can include season snow as a sink for contaminants.

A Snow sampling options

Image 1. Study plot with snow boards for collecting a desired time periods amount of sample.

Image 2. Federal Snow sampler from GeoScientific.

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