Science Permit

Brief Description

The purpose of the proposed experiment is to determine the chemical changes caused by wildfires in ecosystems, specifically Boreal forests. The experiment is designed to gain an understanding of the magnitude and complexity of these chemical changes in the soil. Sulfur and phosphorus will be the primary focus of the study. Examining the speciation, concentration and distribution of these elements in the soil and throughout the various soil horizons will develop an understanding of the soil quality and the effects fire has on the local ecosystem. To test the hypothesis, a series of scans will be conducted on samples of soil, both affected and not affected, at various depths. A few more scans will be taken on standards and compared to other samples to look at any differences between the oxidation states of both, the fire affected and unaffected samples. Upon completion of the experiment, the team hopes the results will help us better understand the positive or negative effects of forest fires on soil chemistry. Specifically in regards to soil nutrients such as sulfur, phosphorous. This study can bring forth new information about the effects of forest fires. This new information can help in the recovery of soil after a forest fire and also make way for more research in this field.

Societal and Economic Impact

The topic of what happens to organic matter when exposed to extreme heat is a complex matter and is not fully understood by soil scientists. In our project we hope to shed a light on the chemical changes in soil when exposed to extreme heat. This information will allow Parks Canada and other environmental studies to better understand the aftermath of fires on the wildlife and the ecosystem affected. The fire in Fort McMurray is an ideal place to gather samples from as it is close to our school in Calgary, and its residents and ecosystem are still experiencing the impact of the large-scale forest fire in 2016. The project intends to gather more information about this environmental issue that regularly happens throughout Canada and the world.

Value of the Results and Industrial Relevance

Approximately 42% of Canada’s landmass is covered in forest, most of which resides in the Boreal Forest located in the northern regions of Alberta and Canada. This forested region serves as a major contributor to Canada’s natural resource exports while also being a vast, unique and important ecosystem. Remarkably, Canada’s Boreal Forest accounts for 10% of the world's forested land. Forest fires are a common occurrence, functioning as both negative and positive events, ultimately affecting the local ecosystem in one of such ways. These effects can be traced deep into the soil of the affected region. The full extent of the influence of forest fires is currently not well understood; minimal research has been conducted to study the behaviour and potential changes of Sulfur in the soil. Results will enable environmentalists, developers, biologists, and soil scientists to better understand such changes. Additionally, it may aid in the development of products or procedures that can improve forest recovery following a fire. This research may introduce new methods of exportation of Canada's forests; ideally, in a more environmentally friendly manner, while helping to preserve and maintain the forest ecosystem. The aim of this project is to bridge the gap between fire and its relation to soil in forested and non forested areas. Through our results, we hope to expand upon this knowledge and identify other new and key components regarding the influence of forest fires.

Scientific Merit

The 2016 Fort McMurray forest fire was a devastating and costly disaster which burned down thousands of homes, displaced thousands of people, and destroyed hundreds of kilometers of forest. The extent of the damage remains unknown, and little is understood as to whether or not its effects are beneficial for the environment. The 2017-2018 SotB group has decided to examine soil in effort to understand the effects of forest fire on soil chemistry; specifically, we will be looking at the changes in the concentrations and oxidation states of sulfur & phosphorus. We chose a small area in Gregorian Lake Provincial Park to obtain samples; certain areas were unaffected by fire, and other areas weren't, providing a basis for comparison. Samples were taken from 3 areas of affected region, and 3 areas of unaffected regions, each approximately the same relative distance from one another. At each of these areas, 3-4 holes at approximately 20-30cm were dug as a precaution to compare the soil's profiles so as to remain relatively consistent. From these holes, one is to be used to obtain samples. All holes were documented and photographed. Samples were taken as follows: An Organic (surface) Layer, Mineral Layer @ 2cm, Mineral Layer @ 5cm, Mineral Layer @ 10cm. In total this yields 24 samples. These will be narrowed down to the samples that will most likely contain the highest concentrations of the elements and species of interest: sulfur and phosphorous. Sulfur has the largest role in the environment; a possible pollutant and vital nutrient for plant or bacterial growth. Phosphorous is part of a large cycle that carries nutrients throughout the soil and is the backbone for many chemical processes. We intend to carry out XRF and XANES scans with the low energy crystal using the IDEAS beamline. Sulfur, and phosphorous standards will be used to perform linear combination fitting; this will provide a basis for comparison so we may determine the specific species in our samples. From our research thus far, we predict that the layers closest to the surface will have greater concentrations of each element, and/or will experience the most substantial changes in its soil chemistry. The results are significant, as they may provide insight into the quality of the soil, and whether fire can affect those characteristics. Soil is relevant to agriculture, mining, water quality and biological processes in the ecosystem. If there is a change in the concentrations and oxidation states of elements in the soil, there may also be a change in the ecosystem and variation of species in the Fort McMurray area.

Past Productivity

In October of 2016, five of the students on this team conducted research at the CLS . The 2016 team worked on a project examining the changes in the concentration and oxidation states of Chromium (VI), Chromium (III) and Arsenic in the tailings ponds of Northern Alberta. The Team discovered that there is not a significant or measurable amount of Chromium (VI) or Arsenic in the tailings ponds. There was evidence that the Chromium (III) species can be found in the tailings ponds. We also concluded that the bitumen extraction process does little to remove this elemental species from the ponds. The poster created for this project won the 2017 Students on the Beamline Poster Contest. Bishop Carroll has been sending a team to the CLS for 7 years straight and has had the privilege to work on a wide range of projects. Previous research has involved heavy metals in cow's milk, and the process of bacteria denaturing naphthenic acid in the tailings ponds.

Experiment Procedure

The XRF and XANES scans will be using the low energy crystal. The estimated time for an XRF scan is 5-10 minutes, and for a XANES scan is approximately 20-30 minutes. The XANES data will be analyzed using linear combination fitting.

Samples: (Affected=Wildfire, Unaffected=No Wildfire)

Source 1 (Affected Region)
- Organic (Surface) Layer
- Mineral Layer (2 cm deep)
- Mineral Layer (5 cm deep)
- Mineral Layer (10 cm deep)

Source 2 (Affected Region)
- Organic (Surface) Layer
- Mineral Layer (2 cm deep)
- Mineral Layer (5 cm deep)
- Mineral Layer (10 cm deep)

Source 3 (Affected Region)
- Organic (Surface) Layer
- Mineral Layer (2 cm deep)
- Mineral Layer (5 cm deep)
- Mineral Layer (10 cm deep)

Source 1 (Unaffected Region)
- Organic (Surface) Layer
- Mineral Layer (2 cm deep)
- Mineral Layer (5 cm deep)
- Mineral Layer (10 cm deep)

Source 2 (Unaffected Region)
- Organic (Surface) Layer
- Mineral Layer (2 cm deep)
- Mineral Layer (5 cm deep)
- Mineral Layer (10 cm deep)

Source 3 (Unaffected Region)
- Organic (Surface) Layer
- Mineral Layer (2 cm deep)
- Mineral Layer (5 cm deep)
- Mineral Layer (10 cm deep)

All Possible Standards

Potassium Phosphate monobasic
Potassium Phosphate dibasic
Potassium Sulphate
Ferric Sulphate
Calcium Sulphate
Elemental Sulfur
Copper Sulfide
Potassium Magnesium Sulphate
Ferric Phosphate
Calcium Phosphate
Aluminum Phosphate
Magnesium Phosphate Mg3 (PO4)3
Iron (II) Sulfide
Zinc Sulfide

We Will be Studying the Oxidation States
Sulphate (+6) using Ferric Sulphate
Sulfide (-2) using Iron(II) Sulfide
Elemental Sulfur (0) using Elemental Sulfur
Phosphate (+5) using Potassium Phosphate monobasic or Ferric Phosphate

Procedure for Comparing Soil Depths

1) Run XRF scans on 2 samples, from wildfire source 1 and from no wildfire source 1 at the 2cm depth.
2) Run XANES Sulfur scan wildfire source 1 at the 2cm depth.
3) Run XANES Sulfur scan no wildfire source 1 at the 2cm depth.
4) Run Standards scans for Ferric Sulphate, Iron(II) Sulfide, Elemental Sulfur, Potassium Sulphate, Copper Sulfide, Zinc Sulfide and Calcium Sulphate
5) Run XRF scans on 2 more samples, from wildfire source 1 and from no wildfire source 1 at the 5cm depth.

6) Run XANES Sulfur scan wildfire source 1 at the 5cm depth.
7) Run XANES Sulfur scan no wildfire source 1 at the 5cm depth.
8) Run XRF scans on 2 more samples, from wildfire source 1 and from no wildfire source 1 at the 10cm depth.
9) Run XANES Sulfur scan wildfire source 1 at the 10cm depth.
10) Run XANES Sulfur scan no wildfire source 1 at the 10cm depth.
11) Run XANES Phosphorous scan wildfire source 1 at the 2cm depth.
12) Run XANES Phosphorous scan no wildfire source 1 at the 2cm depth.
13) Run Standards scans for Potassium Phosphate monobasic, Ferric Phosphate
14) Run XANES Phosphorous scan wildfire source 1 at the 5cm depth.
15) Run XANES Phosphorous scan no wildfire source 1 at the 5cm depth.
16) Run XANES Phosphorous scan wildfire source 1 at the 10cm depth.
17) Run XANES Phosphorous scan no wildfire source 1 at the 10cm depth.
18) *Repeat for Second Wildfire and no wildfire source if there is extra time*