The effects of rain on Elemental Transport in soils

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Introduction

Landscape Evolution Observatory (LEO) is sized 30 meter in length by 11 meter in width covered with a 1 meter layer of granular basalt rock at an average 10° slope inside a climate controlled environment. LEO aims to understand how soil, water and air interacts spatially and temporally[1]. miniLEO, approximately 2-m length by 1-m width and 2-m deep, was constructed to test small scale experiments prior to implementation on the full scale LEO slopes.

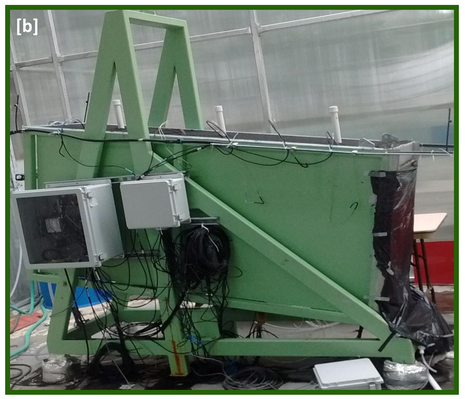
Objective

For this experiment, rain events occurred three times a day in two hour increments at a rate of 30 mm/hr for 14 days to determine if exchangeable ions and targeted elements dissolve over time.

Targeted elements and ions include:

- Total amount of Carbon (TOC)
- Total Inorganic Carbon (TIC)
- Total Nitrogen (TN)
- Bromide
- Chloride
- Fluoride
- Nitrite
- Nitrate
- Phosphate
- Sulfate
- Ammonium
- Calcium
- Magnesium
- Potassium
- Sodium

The results of this miniLEO experiment were compared to previous LEO experiments.



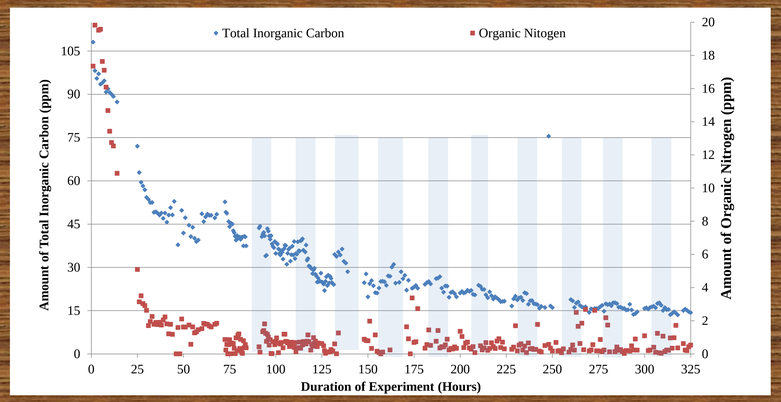
[a] Front view of miniLEO
[b] Side view of minLEO
[c] Anticipated LEO experiment design[2]

Methods

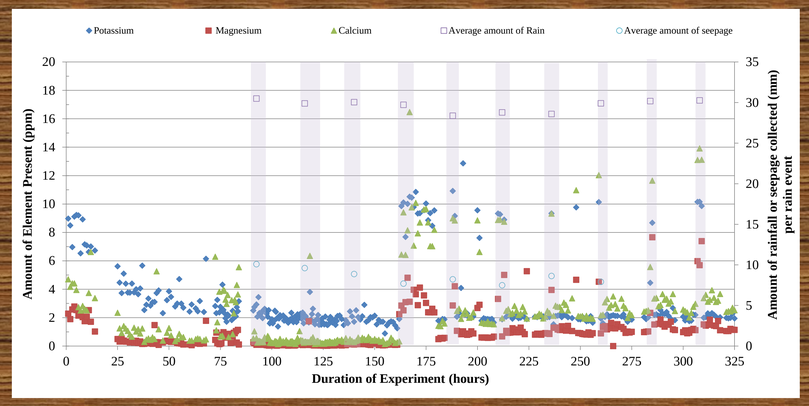
Step 1
- Auto sampler collected ~45 mL of rainwater seepage samples in half hours increments for 14 days

Step 2
- Each sample was tested for:
  - pH & Electric Conductivity
  - Total Carbon, Total Inorganic Carbon, and Total Nitrogen with an aqueous carbon analyzer
  - Exchangeable ions with Ion Chromatography

Results



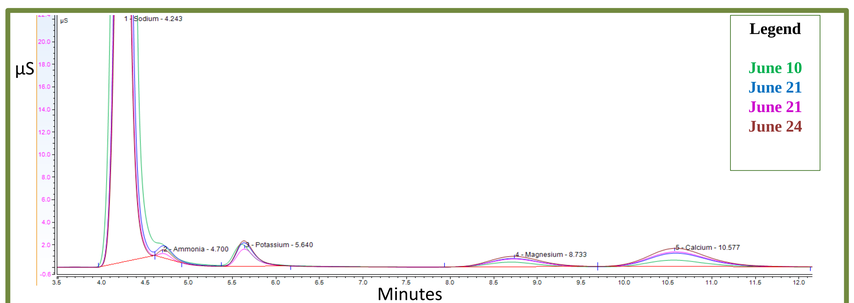
The data points on the primary y-axis depict the concentration of Total Inorganic Carbon (TIC) present and the data points on the secondary y-axis show the concentration of Organic Nitrogen (ON) of the experiment. The blue shaded regions emphasize the relationship between the increase and decrease in concentration of TIC and ON during rainfall and water discharge events, respectively.



The primary y-axis on the graph above demonstrates elemental concentrations of Potassium, Magnesium, and Calcium during the experiment. The secondary y-axis shows rainfall and discharge events. The blue shaded regions highlight the change in concentration of the ions at each rainfall and discharge events, respectively.

Results Comparison

miniLEO Results	Previous LEO Results
• Average pH 9.0 in seepage sample	• Average pH 8.6 in seepage sample
• Decrease in Electric Conductivity	• Decrease in Electric Conductivity
• All ion concentrations demonstrate a decreasing trend	• Approximately 3:1 Carbon-Nitrogen Ratio
• Approximately 3:1 Carbon-Nitrogen Ratio	• TIC fluctuated but generally increased
• Decrease in both ON and TIC	• ON concentration decreased
• The concentrations of Potassium, Calcium and Magnesium decrease until about half way through the experiment then gradually increase	• The concentrations of Potassium, Calcium and Magnesium fluctuate in a decreasing wave-like motion



The above chromatogram demonstrates the integration of the targeted cations using ion chromatography. The y-axis depicts the intensity of the cations detected compared to the amount of time it took for for each ion to elute out of the column.

Discussion

Calcium and Magnesium

- Generally the amount of Calcium and Magnesium decreased; however, a sudden increase occurred approximately half way through the experiment
  - Amount of dissolved CO_2 in system increased→ higher affinity for ion exchange
    - Formation of Calcite and Magnesium Carbonate
      - $Ca + CO_2 \rightarrow CaCO_3$
      - $Mg + CO_2 \rightarrow MgCO_3$

Potassium

- Dissolved Potassium combines with other minerals to form Orthoclase, decreasing the concentration of Potassium ion in solution
- Potassium is leached from Orthoclase, which increases the concentration of Potassium ions in solution and creates Kaolinite

$$\underset{\text{Orthoclase}}{4KAlSi_3O_8} + 4H^+ + 2H_2O \rightarrow \underset{\text{Potassium Ion}}{4K^+} + \underset{\text{Kaolinite}}{Al_4Si_4O_{10}(OH)_8} + \underset{\text{Quartz}}{8SiO_2}$$

3:1 Carbon to Nitrogen Ratio

- Carbon to Nitrogen Ratio in soil is usually 8:1
  - The concentration of Organic Nitrogen decreased
    - Possibly greater amount of denitrifying bacteria compared to the amount of Nitrogen-fixing bacteria
  - Without vegetation there is no photosynthesis occurring
    - Inorganic Carbon is not converted to Organic Carbon
    - Limited amount of organic matter available for decomposition

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References
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