Handout: Environmental Field Analysis

Work Plan

The goal of this trip is to identify the processes that control the geochemistry of Lake Windermere. We want to understand how the catchment water chemistry evolves and how the chemistry changes in the lake itself. The story will be summarized by a box model of the lake.

1. Monday: The stream chemistry reflects atmospheric input and weathering reactions with the surface geology; we will sample streams in the hill above Windermere to see how this evolves. We will take a number of streamwater samples and, in the field, measure pH, electrical conductivity, and alkalinity (essentially, HCO_3^-). We'll take the samples back to Bristol to be analyzed for major cations (Na, K, Ca, Mg) using ICP-OES and anions (Cl, NO_3^-, SO_4^{-2} and PO_4^{-3}) using ion chromatography (IC). Trace metals such as Cu and Zn will also be analyzed for by ICP-OES.

Streamwater Sampling Protocol: First, make sure each bottle is clearly labelled (using permanent ink) with the grid reference and date. When sampling, rinse the sample bottle with the solution being sampled several times. Do not allow your fingers etc. to touch the sample solution. We will take three samples at each locality: the first sample will be filtered and acidified and will be used for total cation analysis. The second and third samples will be filtered but NOT acidified; this will be used for anion analysis by ICP-OES and alkalinity titrations (done at the trailhead). At each locality, measure the pH and electrical conductivity *in situ* (stick the electrode in the stream, not in the bottle). Allow several minutes for stabilization of the reading and use the temperature correction.

2. Tuesday: Next, we will travel around the lake and take water samples (using the same protocol as above) at all of the streams entering (Rothay, Brathay, Trout Beck, Cunsey and Bleham Beck) and leaving (Levan) Lake Windermere. This will take most of the day.

3. ***Wednesday:*** We will go out in two groups on the boat provided by the Freshwater Biology Laboratory. The first leg will sample the North Basin, the second will sample the South Basin. In each basin, we will take 1 litre water samples as a function of depth using 2 meter intervals to a depth of 20 meters and 4 meter intervals, thereafter. We will process the samples at the FBA lab. We will also take two sediment cores at each locality; these will be carefully processed at the FBA lab that afternoon or the next morning.

Lake Water Handling Protocol: In the FBA lab, take an aliquot (50 ml) of lake water and measure the pH and dissolved oxygen. Pass a known amount (500 ml) of lake water through a pre-weighed filter membrane. This will be used to measure the particulate fraction of each element. The filtered lake water will be used for ICP-OES and IC analysis. Dry the filter membrane and record the new weight. The filter membrane and particulate residue will be digested at Bristol and analysed by ICP-OES for major elements (Na, K, Mg, Ca) and trace (Fe, Mn, Zn, Cd, Cu and Pb).

4. Thursday: We will finish processing the lake water and sediment samples to tack back to Bristol.

Sediment Core Handling Protocol: Using the plunger, push out 2 cm of sediment from the core tube and put that in a centrifuge tube. Do this for the entire core and make sure the centrifuge tubes are carefully labelled with the depth interval that it was taken from. Centrifuge the tubes at 3000 rpm for 10 minutes to separate the pore-water from the solid mud. Measure the pH and dissolved oxygen of the porewater. Be sure to carefully rinse the electrodes so as not to contaminate the porewater! Filter 10 ml of the porewater into a tube for later analysis by ICP-OES and Ion Chromatography at Bristol. Save the solid residue; this will be digested using HNO3/HCl at Bristol and analysed for Cu, Zn, Pb and Cd by ICP-OES.

5. Next Monday to Wednesday at Bristol: Water samples will be analysed by ICP-OES and IC under the supervision of Chung Choi. We now have autosamplers so the analyses can be run overnight. You must set up a digestion for the sediment and filter samples using HNO3/HCl.

Streamflow data

To calculate our fluxes, we need to know the discharge rate of each stream. We will not be measuring flow-rates for each stream; instead, we'll use average values from the National River Flow retrieval service

http://www.nerc-wallingford.ac.uk/ih/nrfa/river_flow_data/nrfa_retrievals.htm

For purposes of calculating our fluxes, use these values:

Stream	**Mean flow (m3/s) into Windermere**
Station 73013 - Rothay at Miller Bridge House	4.20
Station 73014 - Brathay at Jeffy Knotts	4.60
Station 73006 - Cunsey Beck at Eel House Bridge	1.00
Station 73007 - Trout Beck at Troutbeck Bridge	1.40
Bleham Beck (Calculated by Difference)	2.66
73010 - Leven at Newby Bridge FMS	-13.86

Given these values, how big could the average groundwater flux be? Another flux is the outflow from the sewage treatment plant. Try to do some detective work and find out what this might be?

Guidelines for your report:

NOTE: The report is due on Friday, 6 December 2013 at 5:00 pm. Please do not ask for extensions.

One of the learning objectives in this trip is to teach you how to prepare real scientific reports. Hence, I want you to go with the format outlined here so that you can learn how to do this. The first page should be a title page with (on separate centered lines) title of report, your name, unit title, institution and date. The second page should just be an abstract. The rest of the report should have the following sections with appropriate headings (in bold):

1. **Introduction.** In this, you define the problem and give background information such as catchment geology etc.
2. **Methods.** Here you discuss what you did so that others can assess whether it was done correctly. Don't discuss the theory behind ICP-AES or the colorimetric methods etc. Just say what method you used and describe those things that are unique to the study.
3. **Results and Discussion.** Guidance for this is below.
4. **References.**

The whole thing should probably be no more than 20 pages. INCLUDE PAGE NUMBERS. I don't care if you go over a bit and I don't care if you go under. All I care about is content. Do not bind/laminate your reports; just staple them in the upper left hand corner like a real paper. DO NOT MAKE YOUR REPORTS LOOK LIKE MOCK NATURE ARTICLES OR OTHER CUTE GIMMICKS.

Regarding Tables: They should be on separate pages but referred to in the text. Don't report more significant figures than you actually have. For most numbers, this will be 2. Really good volumetric work will give you 3. Gravimetric work will give you 4. Getting the number of significant figures right is very important, so be careful.

Regarding figures: Make each figure, along with its caption, on a separate page and make sure each figure is referred to in the text. Don't use bar charts unless they really help convey and idea. Don't include gridlines. Make axis ticks go inward. Don't use colour unless it really gives additional information (some maps).

Here is a synopsis of what scientific topics I would like you to address and how I will mark the reports.

I. General presentation, quality of English, graphics (20%)

II. Background and Methodology (20%)

-discuss geology of catchment and relate to stream chemistry

-discuss analytical methods (briefly..).

-we will be measuring both cations and anions. In all of your reported tables, be sure to report the overall charge balance of the analysis. This is a useful way to assess the reliability of the data.

III. Weathering and Alkalinity (20%)

-discuss relevant reactions leading to observed alkalinity and major ions

-show ion-excess w.r.t. seawater-derived aerosol (see notes from L2 Env.Geochem). Is there an acid rain input?

-calculate saturation indices of $CaCO_3$, etc.

-an inverse model of the stream chemistry would be a 1st class effort

-Showing some compositional parameters on a map might be nice..

IV. Geochemical processes in the Lake (10%)

-identify conservative vs. scavenged elements from their depth profiles

-identify/discuss redox processes and anoxia if relevant

V. Geochemical processes in the Sediments (10%)

-identify redox processes in the porewater.

-determine fluxes of elements into the water column from porewater profiles and Ficks law.

-analyse the digested sediments for Cu, Zn, Pb and Cd to see the record of trace metal pollution of the lake.

VI. Geochemical Budget for Lake (20%)

-identify and quantify fluxes (input/output streams, sediments, other);

-make a box model; understand relative errors and that input and output fluxes will not be exactly equal..

-estimate residence times of each element; discuss variations among elements

-estimate steady state status; infer other fluxes from steady state assumption.