Marvelous Metal Mopping Mosses

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Introduction

Last year, I explored the properties of the fascinating bog moss called *Sphagnum*. This moss can absorb water up to 27 times its dry weight. During my research, I discovered *Sphagnum* also can absorb and hold heavy metals[1]. One of the major pollution issues is heavy metals. They come from many human sources and can cause serious damage to the health of people and the ecosystem. A substance that concentrates them, a bioacumulator, can be very useful in two ways. It can tell us when there are dangerous levels of metals in the environment and it can help clean up those metals. Bogs are especially good at bioaccumulation because they are full of *Sphagnum*.

Purpose

Experiment 1: To find out how much and how fast *Sphagnum* will absorb metals.

Experiment 2: To discover if the bogs truly are polluted with heavy metals and if the mosses are good indicators of heavy metals

Experiment 3: To find out if Sphagnum could be applied as a bioindicator in storm drains.

Sphagnum pacificum is native only to the west coast. It is in all the bogs I collected from.

Sphagnum capifollium is one of the more common species of sphagnum. It comes in shades ranging from red to green. It is found in many bogs in North America.

Bogs are areas of pools of water covered with a mat of Sphagnum moss. There are few left on the coast.

Sombrio (SB): Sombrio Bog lies beside a low-use coastal road, surrounded by a logged fir forest. Otherwise human impact is low. There are many types of *Sphagnum* there, including p*acificum.*

Rithet's (RB): Rithet's Bog is in Saanich, Victoria. It used to be a farm, and is now in the middle of a residential area. The *Sphagnum* has all but disappeared from the bog, leaving only about 4 square meters in the very center of the bog. This is all *S. pacificum*.

Burns (BB): Burns Bog is in the center of Delta, BC beside four highways. The Vancouver landfill lies in the southwest part of it, making pollution highly likely. The bog was used for peat harvesting. The *Sphagnum* species include *tenellum*, p*acificum* and *capifollium*.

Hypotheses

Experiment 1: The moss will take up the test metal in a short period of time (minutes).

Experiment 2: Sphagnum will have more heavy metals in it than the water. I also believe that Burns bog will be the most polluted. Rithet's will be next most polluted and Sombrio the least.

Experiment 3: The moss will be a good bioindicator of heavy metal pollution in the storm drains

Methods

Collection: All mosses were collected in January, using sterile gloves and sterile zip-lock bags. For the bog water, I rinsed the sterile bottle twice before filling it.

Expt 1 – **Copper absorption**: The HACH Cu-6 kit uses Sodium Bicinchoninate, which turns purple in the presence of free dissolved copper. The intensity gives the amount. I had to re-calibrate with standard solutions. I dried my moss for 24 hours in an oven at 120°C and weighed it out into roughly 400mg lumps.

Expt 1.1: I placed the moss in 40ml of $CuSO_4$ solution containing 5mg/L of copper for 10 sec, 1 min, 15min and 24 hour. I then measured for the amount of copper left in the water.

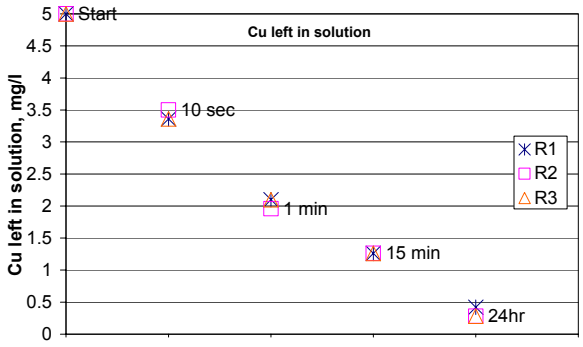
Expt 1.2 : I squeezed the water from the inside of the mosses from 1.1, all the ones from one time together, and measured that. I wanted to know if the copper was in that water.

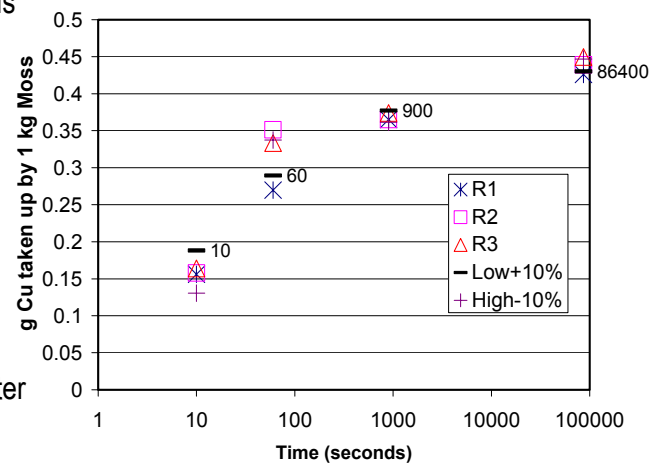
Expt 2 – Metals in bogs: The best way to measure heavy metals is to use an Inductively Coupled Plasma Mass Spectrometer (ICPMS). I used the one in the ICPMS Laboratory at the University of Victoria (SEOS)[3]. Under the supervision of Dr. Richard Cox, I prepared both moss and water samples for measurement in the machine. Dr. Cox ran them for me.

Expt 3 – Storm Drain: The Victoria city pollution abatement officer, Gray Pleven, put my moss down a storm drain (Catchments 626). This is near an old foundry, so the metal contents there are high[2]. I put the moss in panty hose inside a mesh bag and left it there for 17 days. I also got 1 water sample.

Results

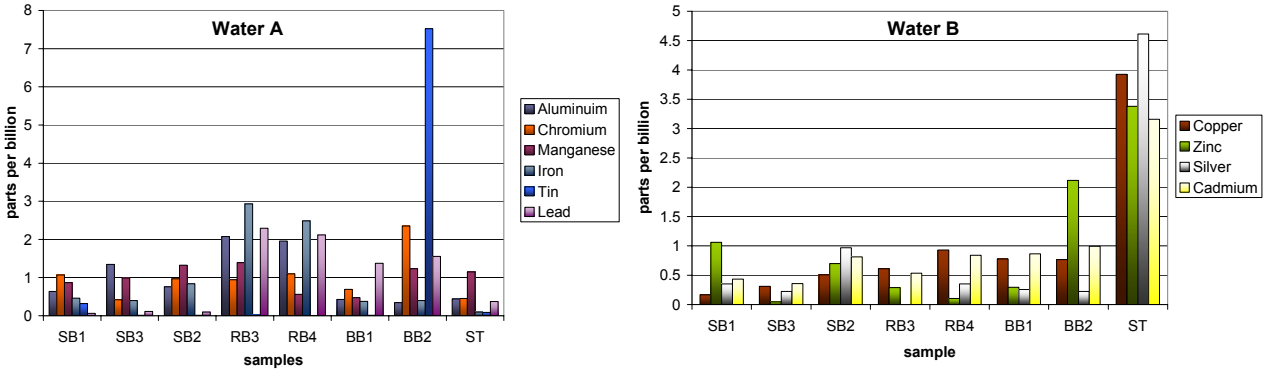
Experiment 1 Copper Uptake: Only a little absorption happened in the first 10 seconds. By 1 minute, half the copper has been absorbed. By 24 hours, almost all of it is absorbed. I would say that the most copper is absorbed in the first 5 minutes or so. To calculate how much moss you would need to take up certain amount of copper in a certain amount of time, here's the chart for you. The Y axis is grams of Copper taken up by 1 kilogram moss in the four test intervals.





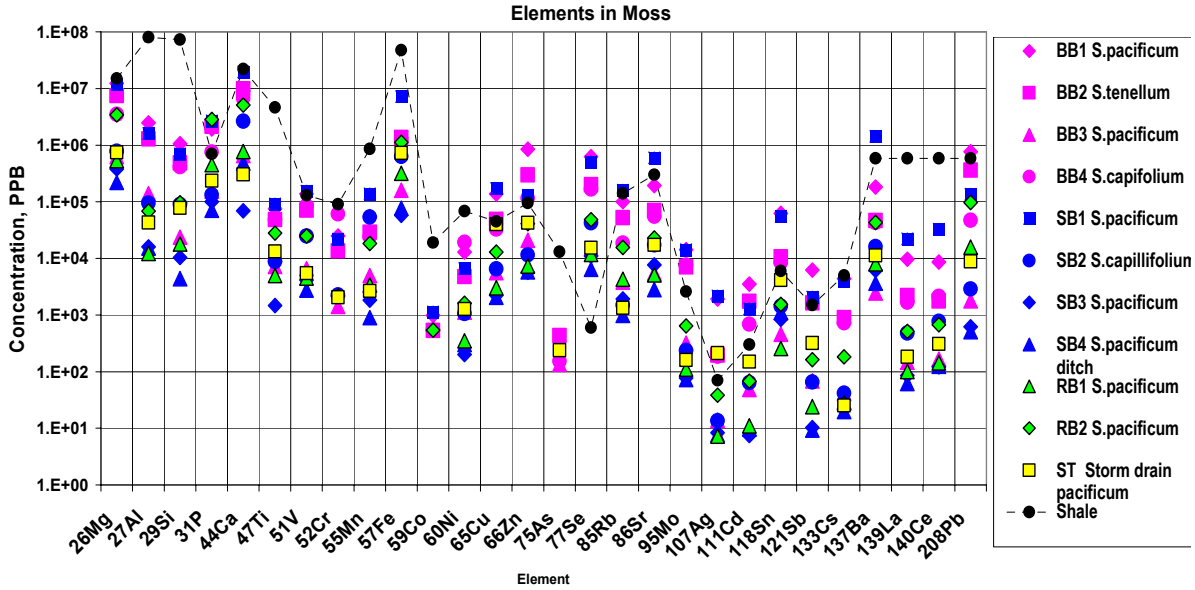
Experiment 1.2: There was very little copper in the water in the moss. This confirms my hypothesis that the copper is held inside the moss cells. The level was less or about the same as in the water outside, and also dropped. Interestingly, the levels inside stay the same after 15 minutes, while those outside keep dropping.

Experiment 2 – Metals in Bog



Experiment 2.1: Rithet's Bog water has the highest levels of four elements (A) and Burns 2 has the highest of two. The storm drain has the highest concentrations of the four shown in graph B. Burns 2 appears to have tin in a concentration much higher than all the other metals.

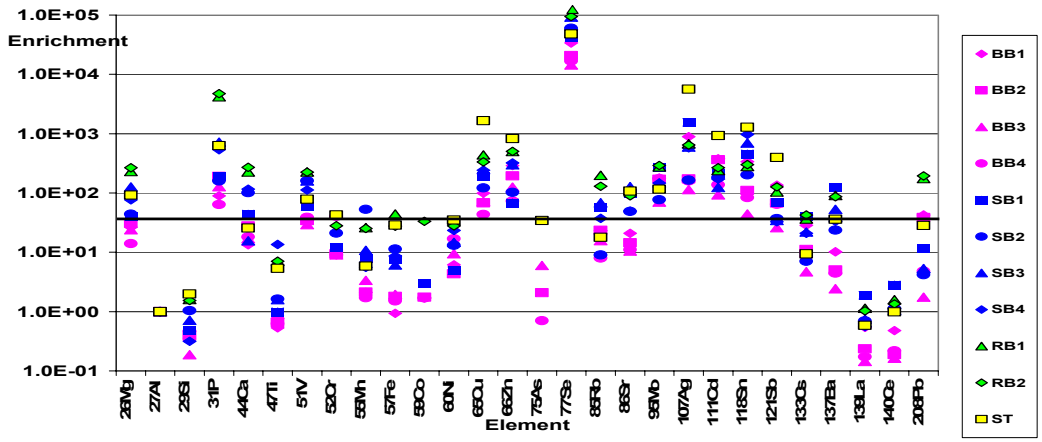
Experiment 2.2: The raw data from the ICPMS, were very confusing. Some numbers were sky rocketing high compared to the others. In the graph, note how BB1 and SB1 are always at the top.



I went to Dr. Kevin Telmer at UVic to try to find out how to interpret the data. He showed me a method used by geochemists to find unnatural contamination, the enrichment factor (EF).

EF = (Element in Moss / Aluminum in Moss)/(Element in Shale / Aluminum in Shale)

He suggested I compare my samples to shale because it is the compressed form of the most common dust, clay. I use Al because it is nearly insoluble by water. If the EF is over one, then the moss is enriched compared to shale, but for it to actually be significant the EF should be over 100. Higher is more interesting. Out of 33 elements I had 9 where the majority of samples were over 100.



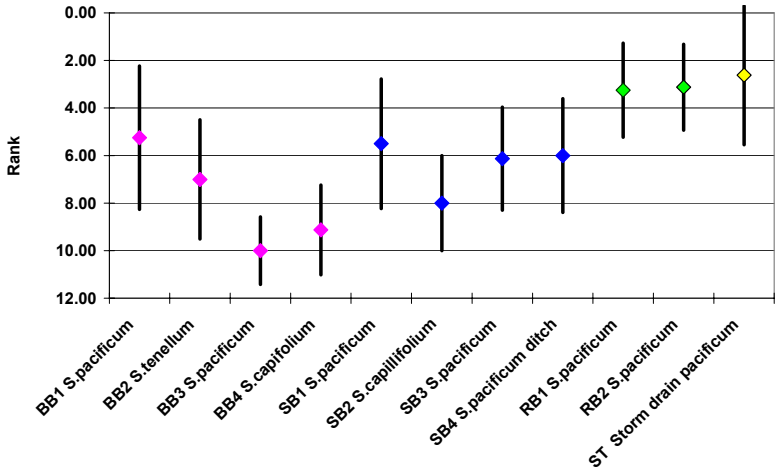
Here are the average EFs for each bog. I added the average without Se (Selenium) because Se is much higher than all the others, so the one without Se is more representative.

I compared the samples, ranking them from largest (#1) to smallest (#11) for each element. The table below is the average rank for each sample. The graph beside the table shows the average and Standard Deviation (the vertical lines).

Sample	Average EF	Average w/o Se
BB1	1345	101
BB2	793	57
BB3	561	31
BB4	633	36
SB1	1694	136
SB2	2354	62
SB3	3830	145
SB4	2400	146
RB1	5445	338
RB2	3810	333
ST	2215	461

Bog	Average EF	Average w/o Se
SB	2570	122
RB	4627	336
BB	833	56
ST	2215	461

Aluminum	Average	St Dev
BB1 S.pacificum	5.25	3.01
BB2 S.tenellum	7.00	2.51
BB3 S.pacificum	10.00	1.41
BB4 S.capifolium	9.13	1.89
SB1 S.pacificum	5.50	2.73
SB2 S.capillifolium	8.00	2.00
SB3 S.pacificum	6.13	2.17
SB4 S.pacificum ditch	6.00	2.39
RB1 S.pacificum	3.25	1.98
RB2 S.pacificum	3.13	1.81
ST Storm drain pacificum	2.63	2.92



Experiment 3:

All my data is on the graphs from Experiment 2. The storm drain moss is one of the highest EFs in metals and is highest in Sl, Cr, Nl, Cu, Zn, As, Sr, Ag, Cd, Sn and Sb. Most of the other times it is second or third, beaten by the Rithet's moss.

Discussion

Experiment 1: *Sphagnum* both absorbs and holds heavy metals: it is the ideal bioacumulator. Not only could it be used as an indicator, it could also be useful as a cleaner after spills. It absorbs both metals and water quickly and is light to carry. This makes it perfect. I have not yet discovered where it stored the metals. They are not in the water inside or out, so I assume they are tucked away in the actual moss cells. I left the 24hour sample in distilled water to see if any copper came out, but it stayed in the moss.

Experiment 2: As much as I'd like to, I will not assume that high metals are pollution. Pollution is environmental contamination with man-made waste. Not all metals in the bog may come from man. Some may come from mineral deposits beneath or around the area. Also the metal accumulates over a long time. You may look at the moss and say "That's a lot of metal. It must be polluted!" It has been collecting those metals for a while, so you have to be careful. For most elements the pattern is Storm Drain > Rithet's> Sombrio> Burns. This is not what I expected. I thought Burns would be highest because of the land fill , but the highway at Rithet's may actually be closer to the sampling site. There also used to be a copper mine above Rithet's, and it's in a residential area. I thought Burns would be higher than Sombrio too, but it was not. This may be because my collection site was only about 30 meters from the road and the area around it had been clear cut a while ago so sediment may have washed into the bog. Burns may actually have been the most isolated sample site, though it was surrounded by contamination sources.

Experiment 3: The storm drain moss turned out the way I expected. It had high EFs in most metals. I believe all the metals it took up were dissolved. But there are some metals that it does not give readings that correspond to the water concentrations.

Conclusions

Experiment 1: The moss can take up heavy metals in short periods of time. It can take up half of the metal in the water in minute, an even shorter time than I thought. It continued absorbing for a long time, but much of it is done very quickly, making it good for cleaning up metal spills, quick and efficient!

Experiment 2: Sphagnum is very good at absorbing metals. It reflects the amount of metals in its environment well. However it takes a lot of manipulation and research to tell if there is pollution.

Experiment 3: Sphagnum is a good indicator of metals in places like storm drains, but not totally reliable.

Overall: *Sphagnum* would make a great biomoniter because it absorbs dissolved metals quickly and efficiently, but it is less reliable than I first thought.

Acknowledgments: Thank you to Karen Golinski, for showing me around Burns Bog.
Sharon Hartwell collected for me in Rithets Bog, where I couldn't go. Thanks!
Dr. Kevin Telmer at the University of Victoria let me use his ICPMS and

Dr. Richard Cox showed me how to prepare the samples, explained the ICPMS and ran my samples.Thank you!

Gary Pleven and Rich from the City of Victoria put my moss in Catchment 626 and got it out. Thanks.

Dad drove, was a field asistant and showed statistics. My mother purchased the copper kit and showed me calibration. They both made sure I actually did it. Oh, and they let me take over the upstairs bathroom.

References:

[1]Adamo P, Giordano S, Vingiani S, Cobianchi RC, Violante P, Trace element accumulation by moss lichen exposed in bags in the Naples (Italy), Environmental Pollution,[2]Cameron R., Miller R., 2002 Stormwater Quality Annual Report, Capital Regional District,[3]*University of Victoria I*CPMS Laboratory with Laser Ablation Microprobe http://web.uvic.ca/~icpmslab/

I used other sources of information too. They are listed on the poster display.