The Role of Bedrock Geology and Forest Canopy on Soil Chemistry at the MacLeish Field Station

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Introduction

Soil chemistry is a crucial component in fresh water systems due to its influence on stream chemistry. After entering the system as precipitation, water infiltrates through the soil profile prior to contributing to the base flow of the watershed. Mineral weathering reactions in underlying bedrock and cation exchange reactions in soils moderate stream chemistry characteristics such as acid neutralizing capacity (ANC) and soil chemistry characteristics such as cation exchange capacity (CEC), total acidity, and base saturation. We analyzed these characteristics to determine the MacLeish Field Station’s vulnerability to acid inputs. Questions under investigation included:

1) Is acid deposition affecting stream and soil chemistry at the MacLeish Field Station?
2) Which reactions (mineral weathering or cation-exchange) are most significant in determining stream and soil chemistry at the MacLeish Field Station?
3) Is variation in bedrock geology and forest canopy resulting in differences in stream and soil chemistry between the western and eastern sites at the MacLeish Field Station?

Methods

Stream and soil samples were collected from both the eastern (JNB) and western (WTA) regions of the MacLeish Field Station and analyzed for pH using a portable Fisher Scientific Accumet AP 62 pH meter. Soil color for each horizon was determined using a Munsell soil chart.

Acid neutralizing capacities for streams sampled at the MacLeish Field Station were determined by the Gran function method and the inflection point method using a QC-TIS titrator equipped with an A M HIO reference electrode whereby HC (0.02 N) was added in varying volume increments to each stream sample.

Total cation exchange capacity and exchangeable base cation concentrations (Ca2+, Mg2+, K+ and Na+) were determined by titration using NaOH (0.1 N) and back-calculated with HC (0.01 N). Anion concentrations (SO42-, NO3-, Cl) were determined by IC analysis with a Dionex ICS 9000 ion chromatograph equipped with a Dionex AS94 column.

In the soil samples JNB 0.0-1.5 cm, WTA 0.0-4.0 cm, WTA 36.0-40.0 cm, and WTA 62.0-75.0 cm, the concentration of certain base cations exceeded the concentration of the standards. These soil samples were diluted by 10% and then reanalyzed by IC-IES analysis.

Field Description

The JNB soil samples were collected near Jimmy Nolan Brook on the eastern boundary of the MacLeish Field Station where the underlying bedrock is comprised of both schist-marl and schist-chert (Figure 3). Surrounding vegetation is deciduous and consists predominantly of sugar maple and tanoak and white haws ferns (Figure 4). The JNB soil pit was dug on a hill slope and contained a thin organic layer, an A horizon, a B horizon, and a possible C horizon (Figure 1).

The WTA soil samples were collected near a seep along the western boundary of the MacLeish Field Station where the underlying bedrock is comprised of granodiorite, schist-marl, and schist-chert (Figure 3). Surrounding vegetation is predominantly hemlock (Tsuga canadensis) (Figure 4). The WTA soil pit contained a thicker organic horizon than the JNB soil pit, as well as the weak development of a translocated O horizon which was identified by patches of black and white coloration (Figure 2). The WTA pit also contained an A, B and C horizon (Figure 2).

Soil Chemistry

Total cation exchange capacities for soils at the JNB and WTA pits. Total acidity was, on average, higher for the WTA pit compared to the JNB pit. (Note: The total acidity and exchangeable aluminum concentrations for the B horizon at average depths of 71.5 and 92.0 cm and for the C horizon are identical so the curves are overlapping at these points.)

Discussion

ANC values for streams sampled at the MacLeish Field Station were relatively high, ranging from 438.4 (WB 200) to 233.3 (JNB 100). ANC values in excess of 50 μeq/L indicate that streams sampled at the MacLeish Field Station are relatively insensitive to inputs from acidic deposition (Driscoll et al 2001). Furthermore, base saturations were relatively insensitive to inputs for both soil pits (Figure 7). Base saturations for all soil horizons (with the exception of the C horizon) at the WTA pit were lower than those at the JNB pit. Consequently, this site has lower soil pHs and base saturations than the JNB pit. The WTA pit also exhibits higher exchangeable aluminum concentrations due to aluminum’s propensity to mobilize in solution under acidic conditions.

Conclusions

1) Streams and soils sampled at the MacLeish Field Station were relatively insensitive to inputs from acidic deposition as evidenced by their high ANC values (>50 μeq/L) and base saturations (>20%).

2) Low cation exchange capacities (characteristic of koolstein) for the soil horizons indicate that cation exchange reactions in soils are having less of an effect on stream chemistry than mineral weathering reactions in underlying bedrock.

3) ANC values and base saturations were higher at eastern sites than western sites. Carbonate mineral weathering was predominant in underlying marble bedrock at eastern sites while silicate mineral weathering was predominant in underlying schist and granodiorite bedrock at western sites. This likely resulted in the observed differences in ANC values and base saturations between the MacLeish sites.

4) The presence of a hemlock canopy and a thicker O horizon at the WTA pit located near the western site resulted in higher total acidity, exchangeable hydrogen, and exchangeable aluminum concentrations as well as lower soil pH and base saturations for soils at the WTA pit compared to soils at the JNB pit located near the eastern site.

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References: