Geophysical Research Abstracts
Vol. 14, EGU2012-9444, 2012
EGU General Assembly 2012

Enzymatic regulation of organic matter metabolism in Siberia's Kolyma River Watershed

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Arctic soils contain vast amounts of ancient organic carbon stored in permafrost that can be unlocked and remobilised via permafrost thaw and bacterial degradation. The mechanisms regulating the release and fate of this carbon are important to understand if we wish to predict future changes in the global carbon cycle.

Microbial communities release enzymes into the environment (ectoenzymes) as a means of degrading organic matter and to acquire carbon, nitrogen and phosphorus for assimilation. We measured potential activities of a suite of ectoenzymes within surface waters collected from a range of streams and rivers throughout the Kolyma River basin, Siberia. Ectoenzyme activities were additionally measured in Kolyma river waters collected at three distinct periods of the hydrograph (under-ice, freshet and summer conditions). Seven enzymes were studied allowing bacterial requirements for a wide range of compounds including lignin, carbohydrates, proteins and cellulose to be assessed. Concurrent measurements of DOC lability were conducted using biological oxygen demand assays conducted over 5 days (BOD).

Phenol oxidase activity was found to strongly correlate to BOD (r2=0.68) and stream CO_2 concentration (r2=0.76) across all of the study sites, suggesting the rate of phenolic degradation may be a controlling factor in organic carbon metabolism. The activity rate in ectoenzymes that catalyze phosphate, lignin and carbon substrates varied significantly within the Kolyma river over the hydrograph, suggesting that seasonal changes in organic matter composition may also shift the limiting resource for bacterial degradation. Extremely high activity rates in ectoenzymes that catalyze lignin, chitin, cellulose and proteins were measured in waters draining permafrost ice complexes.

It is apparent that organic carbon is continually processed throughout the stream network, and that its ultimate fate is linked to organic matter composition. We demonstrate that organic carbon derived from ancient permafrost thaw may be highly biolabile within Arctic aquatic ecosystems.