Tree species influences phosphatase activity and microbial community composition

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Abstract

Tropical forests are an important carbon sink, responsible for cycling more CO_2 and water than any other terrestrial biome. The goal of the Next Generation Ecosystem Experiments–Tropics project is the synthesis of modeling and data to understand feedback systems that influence terrestrial-atmosphere CO_2 flux. This approach locks modeling and data into an iterative cycle that uses models to identify uncertainties and uses data to improve the model. Reduction of uncertainties in global ecosystem models requires the accurate representation of the tropics, which can be improved by including important belowground processes.

One important belowground process is the biological mineralization of phosphorus, which can be considered a limitation to growth in tropical forests, ultimately influencing CO_2 flux. Parent material determines the initial supply of phosphorus, though the amount of it available for plants is usually much less, requiring the release of phosphatase enzymes to supply the inorganic phosphate (P_i) crucial to their growth.

Three forested sites in Puerto Rico – Rio Icacos, El Verde Ridge, El Verde Valley – were chosen to investigate the effect of parent material on phosphatase activity of four common species: *Cecropia schreberiana, Prestoea montana, Cyrilla racemiflora, Dacryodes excela, and Manilkara bidenta*. The two El Verde sites, on volcanistic parent material, and the Rio Icacos site on quartz-diorite form a range of conditions helpful to the development of relationships between edaphic factors and phosphatase enzymatic activity. Fine root clusters collected from three trees of each species were assayed for both types of phosphatase activity: phosphomonoesterase and phosphodiesterase. DNA extracted from the rhizosphere and endosphere of fine root clusters within El Verde Ridge and Valley sites were used for 16S rRNA gene profiling of microbial community composition.

Results from two-way ANOVA indicate the importance of species in determining phosphatase activity, particularly of phosphodiesterase. Within the El Verde sites, ANOVA comparisons of phosphatase activity with respect to species also show that species is an important factor. However, only phosphodiesterase activity was significantly different among species within the Rio Icacos site. Microbial community composition, assessed through QIIME, showed a difference between *Dacryodes excela* and *Prestoea montana.* Comprehension of how phosphorus constrains ecosystem productivity involves determining how individual trees adjust to their local environment, particularly with belowground processes that enhance phosphorus availability.

Nanoscale Mercury Sulfide-Organic Matter Interactions: Practical Applications for Environmental Risk Assessment

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The geochemical speciation of mercury (Hg) is an important factor that controls the bioavailability of this metal to anaerobic microorganisms responsible for methylmercury production in the aquatic environment. In anaerobic settings, Hg is largely associated with sulfides and natural organic matter (NOM). These interactions involve a variety of species, including Hg complexes with thiolate moieties on NOM and HgS nanoparticles that can be stabilized in solution by NOM coatings. This study aims to delineate how the molecular structure of NOM-coated HgS nanoparticles alters the bioavailability of Hg for methylating microorganisms and to use this information for new methods to quantify Hg bioavailability in sediments and other geomedia.

A variety of spectroscopic techniques was used to delineate the structure of HgS nanoparticles as they aged for up to one week in the presence of NOM. These nanoparticles were then amended to cultures of methylating bacteria. The results demonstrated that the methylation potential of HgS decreased with the age of the nanoparticles, and that this trend coincided with an increase in aggregation and crystallinity of the nanoparticles. The amount of dissolved Hg in solution (defined by the fraction passing a 0.02-micron filter or remaining in suspension after ultracentrifugation) was not a good predictor of Hg bioavailability. Instead, bioavailability correlated with the fraction of particulate Hg that dissolved in the presence of glutathione, a thiolate ligand that could be representative of metal binding sites on the bacterial cell envelope. These observations have been used to develop a thiolate-based selective extraction assay for quantifying metal bioavailability in geomedia. Overall, the results of this work suggest that a portion of solid-bound mercury is bioavailable to microorganisms, the reactive fraction depends on the nanoscale structure of HgS, and this fraction can be approximated by a selective extraction assay that can sufficiently mimic processes at microbe-mineral interfaces.