Acid Phosphatase Activity as an Indicator of Phosphorus Status in Riparian Forest Soils

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Principle Investigators

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Problem and Research Objectives

Riparian wetland areas tend to accumulate sediment-bound P that originates from upland areas. In addition to sediment trapping, P removal in riparian areas occurs via plant and microbial uptake and adsorption to soil particles. There is a need for sensitive, fast, and inexpensive method to evaluate the performance of riparian forest soils with respect to P status. The national Research Council's committee on Long-Range Soil and Water Conservation has identified the long-term effectiveness of riparian zones in nutrient and sediment removal as a major concern. Soil acid phosphatases catalyze the hydrolysis of organic phosphate esters to orthophosphate, and thus constitute an important link between biologically unavailable and bio-available P pools in the soil. This research addresses Research Priority Area A--- Watershed/ Ecosystem Management, and specifically Subsection d: Effective management strategies for riparian zones and wetlands protection and assessment of their role in the retention and recycling of nutrients and toxicants. The results of this study will be of use to land and water managers and land-use planners in monitoring the performance or riparian areas and in assessing their role in water quality enhancement.

Methodology

The study is being conducted in moderately well drained and somewhat poorly drained soils in a riparian forest within the Peckham Farm research area of the University of Rhode Island in Kingston, RI. The soil in the upland portion of the catena is mapped as a Hinckley sandy loam, whereas the soils in the lower portions of the catena are mapped as Walpole sandy loam and Scarboro mucky sandy loam. There are four nutrient treatments being applied as 1 cm of simulated runoff to 1 m x 1 m square plots: (1) un-amended control; (ii)control amended with water;(iii)simulated runoff containing P only; and(iv) simulated runoff containing P and N. Nutrients concentrations are applied at a rate of 0.75 kg Phosphate-P/ha(treatment iii) or 0.75 kg phosphate-P/ha and 3 kg Nitrate-N/ha(treatment iv) on every application. Application of simulated runoff has been made in October, and November 1999 and April 2000. Soil cores (5-cm length) have been bulked, sieved and sampled on those dates and in December 1999 and March 2000. Phosphtase activity is assayed twice for each sampling time: once using field moist soil samples immediately after collection and a second time using soil samples that were air-dried for two months. In addition to phosphatase activity measurements, soil moisture content, bulk density, pH(using a 1:10 soil/water (wt:wt) ratio), and bicarbonate-extractable inorganic P are determined.

Principal Findings and Significance

Soil phosphatase activity in both somewhat poorly drained (SPD) soil and moderately well drained (MWD) soil increased in the autumn and remained high in the spring. However, activity was much greater in the SPD soil than MWD soil. Phosphate concentrations are also much higher in the SPD soil than the MWD soil. However, if the data are normalized to soil organic matter content, the phosphates activity in the both drainage classes is similar in the winter and spring. Normalization to soil organic matter is justified because of the great differences in organic matter between these two soils and by the known association of phosphatase activity with organic matter content. Our data showed statistically significant differences in acid phosphatase activity per unit of soil mass among drainage classes within a soil catena, with activity decreasing as drainage improves. Furthermore, acid phosphatase activity in each drainage class showed a statistically significant, positive, and different linear relationship with soil organic matter and moisture. Phosphate levels were fairly constant in the autumn in the MWD soil in all three treatments, but increased in the spring. In SPD soil, the trend was different, with phosphate levels increasing in the autumn in all three treatments, decreasing in the spring in the control and P addition treatment, but increasing in the N + P treatment. Despite the difference in phosphate levels in the SPD soil and the fact that inorganic N additions have been shown to increase phosphatase activity in soils, we still have not observed significant differences in phosphatase activity among treatments in either MWD or SPD soil. Phosphatase assays conducted on field-moist soil are more representative of activity under field conditions and thus are representative of short-term changes in the enzyme pool, such as those resulting from recent changes in enzyme production. By contrast, air-drying has been shown to reduce acid phosphatase activity in soils, apparently as a result of degradation of recently produced enzyme. The enzymatic activity of air-dried soil is associated with protected, particle-bound enzyme and represents long-term changes in phosphatase activity. Much of the total activity in our study is attributable to the labile fraction and not the recalcitrant (dry soil) fraction. Our data indicate that short-term changes (activity in wet soil minus activity in dry soil) in phosphatase levels may be detectable; however, to date, the nutrient additions in this experiment have not resulted in significant differences in phosphatase activity relative to control plots. The results of this study are important for determining (a) whether response of soil acid phosphatase to P and N and P in runoff can be detected against seasonal variations and (b) whether landscape position within a riparian forest influences the ability of acid phosphatase to respond to nutrient disturbances.

Descriptors

Phosphorus, Soil Biochemistry, Runoff, Riparian Forests, Acid Phosphatase

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