USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Acid Phosphatase Activity As An Indicator Of Phosphorus Status In Riparian Forest Soils

Focus Categories: NU WL MET

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

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Non-Federal funds pledged: $29,318

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Congressional district: 2nd

Statement of critical regional or state water problems.

Increased phosphorus concentrations have accelerated the eutrophication of inland lakes and reservoirs in the northeastern U.S. (Frink 1991). Forested riparian areas are among the best management practices (BMPs) recommended for amelioration of nutrients and other pollutants in runoff (National Research Council 1993). Riparian areas are the interfaces between terrestrial and aquatic ecosystems (Gregory et al. 1991) and include both upland and wetland areas. These buffer zones are widely used to remove non-point source pollution from agricultural and urban runoff , and thus serve to improve surface water quality (Jacobs and Gilliam 1985; Peterjohn and Correll 1984; Lowrance et al. 1984). Sediment trapping is an important mechanism of nutrient removal in riparian areas (Lowrance et al. 1984; Cooper et al. 1987). Riparian wetland areas, because of their flatter slopes and high surface roughness, tend to accumulate sediment-bound P that originates from upland areas (Lowrance et al. 1984; Peterjohn and Correll 1984; Vought et al. 1994). For this reason, riparian areas are believed to be important in mitigation of phosphorus present in runoff (Lowrance et al. 1986). In addition to sediment trapping, P removal in riparian areas occurs via plant and microbial uptake and adsoprtion to soil particles (e.g. Lyons et al., 1998). Long-term exposure of riparian areas to elevated P levels can affect the ability of plants, microorganisms, and soil particles to act as sinks for P. Plants and microorganisms acting as sinks can become saturated, such that P is no longer absorbed at a rate sufficient for enhancement of water quality. 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 (National Research Council 1993).

Information on the changes in performance of water quality functions of riparian forests, particularly with regard to P, in terms of dynamics and/or nutrient loading is scant. The methods currently available for evaluating the effectiveness of riparian areas in nutrient removal generally involve generation of a mass balance or budget over the course of a year, with a wide range of temporal sampling scales employed. These approaches can be costly and labor-intensive. The expense involved usually generates a limited data set. Cost also limits the number of sites that can be evaluated. Finally, the results of these studies may not be available for a considerable amount of time after they are conducted. If the riparian buffer area of concern is no longer functioning to remove P, the damage may be done before the information becomes available. Generally, evaluation of the performance of riparian areas is accomplished using models. These functional models can be useful tools for design and management of riparian areas (e.g. Gold and Kellogg 1996). However, they tend to have a relatively high degree of uncertainty associated with predictions of nutrient removal. There is a need for sensitive, fast, and inexpensive method to evaluate the performance of riparian forest soils with respect to P status.

Development of a performance indicator for riparian areas may allow for better management of these landscape features with respect to mitigation of non-point source P pollution and may be helpful in determining the practical limits of such areas with respect to their ability to enhance water quality. This information will be of use to land and water managers and land-use planners in monitoring the performance of riparian areas and in assessing their role in water quality enhancement. Hence, the proposed 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.

Statement of results or benefits

We will evaluate the magnitude and direction of the response of soil acid phosphatase activity in a soil drainage catena within a riparian forest buffer zone to repeated amendments with artificial runoff containing either inorganic phosphorus or inorganic phosphorus and nitrogen over the course of two years. The seasonal component of the variability in response will be established and the relative sensitivity of acid phosphatase in soil from different drainage classes within the catena will be determined.

The results of this study will be used to determine (a) whether the 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. This will allow us to assess whether acid phosphatase activity assays are likely to be reliable indicators of changes in soil P status. This basic information is necessary prior to large-scale field tests of acid phosphatase activity as an indicator of the P status of riparian forest soils and thus their ability to retain phosphorus.

Nature, scope, and objectives of the research

A good ecological indicator should have a number of features, including: (i) show a prompt and accurate response to perturbation, (ii) reflect some aspect of the functioning of the ecosystem; (iii) be readily and economically accessible; (iv) be universal in distribution yet show individual specificity to temporal or spatial patterns in the environment (Holloway and Stork 1991). These criteria are directly applicable to the identification of an indicator of the phosphorus status of riparian areas, inasmuch as elevated nutrient inputs in runoff constitute a perturbation of the riparian forest ecosystem.

We propose to evaluate the activity of soil phosphatases (phosphomonoesterases) (EC 3.1.3) as a potential indicator of the phosphorus status of riparian forest soils. Dick (1991) has suggested that the sensitivity of phosphatase activity to temporal changes in soil due to environmental and management factors makes it a potentially good indicator of changes in soil quality. Soil phosphatase activity meets all the criteria of Holloway and Stork (1991) for a good ecological indicator.

Objectives of the Research

The primary objective of the research is to evaluate soil acid phosphatase activity as a potential indicator of the P status of riparian forest soils. Specifically, we will evaluate:

The sensitivity of soil acid phosphatase activity to P, and P and N, in runoff as a function of landscape position (i.e. soil drainage class) and the relationship between phosphatase activity and soil P levels.

The effects of inorganic P, and P and N, on short and long-term pools of acid phosphatase activity.

1. The temporal variability (both within and between seasons) of the response of soil acid phosphatase activity to inputs of inorganic P, and inorganic N and P, in runoff.
2. The effects of inorganic N on the response of acid phosphatase activity to phosphate additions.
3. Methods, procedures and facilities