WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Field Monitoring of Drainage and Nitrate Leaching from Managed and Unmanaged Ecosystems

Focus Categories: AG, NC, WQL

Keywords: Agriculture, Groundwater, Nitrogen, Water quality

Duration: March 1, 2000 - February 28, 2001

FY 2000 Federal Funds: $15,325

FY 2000 Non-federal Funds: $36,535

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Statement of Critical Regional or State Water Problems

The appropriate balance between profitable agricultural production and environmental degradation is challenging to establish because of the relative ease with which nitrate moves with water through soil. The fertilization of agricultural crops affects nitrate-leaching losses and groundwater quality. In Wisconsin 50 of the 72 counties, potentially affecting 1.5 million people, have medium to high susceptibility for groundwater nitrate leaching from excess applications of nitrogen fertilizer. This story of rising nitrate levels in groundwater is repeated in virtually every agricultural area of the United States. In fact, nitrate levels are so high in the Upper Mississippi River Basin that nitrate concentrations in the Mississippi River have doubled and the flux of nitrate has tripled since 1960 (Bratkovich et al., 1994). This, in turn, has contributed to hypoxic conditions in the Gulf of Mexico (Rabalais et al., 1996).

Statement of Results or Benefits

We will address the priority water quality issue of nitrogen contamination by evaluating the influence of two agricultural management and fertilization practices on nitrogen levels in groundwater. The research will generate a continuous data set from direct field measurements of drainage and nitrate leaching and when combined with similar data collected over the past 4 years, continuous drainage and nitrate leaching data sets of more than 5 years can be assembled for fertilized chisel plow and no-tillage corn and natural prairie ecosystems. These findings will advance the understanding of relationships between agricultural practices and nitrate leaching losses during the growing season and throughout frozen soil periods for several agroecosystems. Researchers, regulators, farmers, and agricultural industries will gain from a better understanding of how to measure and predict water and nitrate movement through unsaturated soil based on actual field measurements of drainage and associated leaching losses. Results from this research should aid in regulatory and on-farm decisions to optimize crop production and minimize contamination.

Nature, Scope, and Objectives of the Research

The overall objective of this research is to continuously monitor water movement (i.e., drainage) and solute leaching, mainly nitrate (NO_3^-) from managed and unmanaged ecosystems on productive silt loam soil using proven equilibrium tension lysimeters. Several specific objectives are proposed to accomplish the overall goal and to further investigate relationships between tillage, soil temperature, drainage, and chemical leaching. The specific objects are to:

- Continue year-round monitoring of drainage and nitrate leaching from pre-existing, optimally N-fertilized, no-tillage and chisel-plowed corn plots and natural prairie;

- Construct and install four equilibrium-tension lysimeters in pre-existing no-tillage and chisel plow corn plots to monitor drainage and nitrate leaching at two reduced levels of N fertilization;

- Determine the extent of cation and heavy metal leaching associated with nitrate leaching from tillage treatments amended with a range of fertilizer N rates; and

- Develop a solute transport subroutine for a landscape-scale, soil-geochemical computer model and validate this model with field measurements.

Two important issues associated with nitrate contamination from agricultural practices are addressed by this research. They are: (1) monitoring optimally fertilized agroecosystems and (2) evaluating mitigation opportunities associated with agricultural management practices. The proposed research incorporates innovative and proven technologies to measure drainage and solute leaching *in situ* from undisturbed soil columns and provides critical, basic knowledge regarding soil hydraulic properties and leaching potentials of a silt loam soil common to most of the agricultural region of Wisconsin.

Methods, Procedures, and Facilities

Equilibrium tension lysimeters will be used to monitor drainage and solute leaching (Brye et al., 1999) from fertilized and unfertilized chisel plow and no-tillage corn plots and from a natural prairie. Leachate samples will be collected biweekly from the lysimeters between April and December, or more frequently depending on extreme precipitation events. Vacuum suction will be used to collect the samples from the lysimeters. The first liter of leachate sampled will be collected in to 1-liter polyethylene bottles and brought back to the laboratory where it will be filtered through glass fiber filter paper and refrigerated to await chemical analysis. Any remaining leachate (>1 liter) will be collected in 4-liter polyethylene bottles, the volume will be measured in the field, and the sample will then be discarded.

Filtered leachate samples will be analyzed for inorganic nitrogen (NO_3^- and NH_4^-), soluble organic carbon, and a suite of cations, including potassium, calcium, magnesium zinc, manganese, copper, iron, sodium, and aluminum. Inorganic nitrogen analyses will be performed by the Wisconsin State Soil and Plant Analysis Laboratory using colorimetric analysis with a Lachat continuous flow ion analyzer. Soluble organic carbon analyses will be conducted by high temperature catalytic combustion using a Rosemount-Dohrmann DC-190 total organic carbon analyzer. Cationic mineral and heavy metal analyses will be determined by the State Soil and Plant Analysis Laboratory using Inductively Coupled Plasma (ICP) spectroscopy.

Related Research:

The proposed research is the continuation of an interdisciplinary study that began in June 1995 to evaluate the cycling of water, nitrogen, and carbon in managed and unmanaged ecosystems. This project proved extremely successful and provided the only site in the Midwest monitoring the major components of the N budget on undisturbed, agriculturally productive silt loam soils.

The main focus of the original project was to assess the drainage and inorganic N leaching components of the hydrologic and N cycles in order to construct annual budgets from independent field measurements. Results of measured drainage, soil moisture storage changes, precipitation inputs, and snow cover moisture storage were synthesized into an 82-week water budget where evapotranspiration was calculated as the residual of the water budget (Brye, 1997). In addition, field measurements obtained during the study were used to test a model that simulated drainage, soil moisture storage changes, and evapotranspiration (Brye et al., 2000). Seasonal evapotranspiration estimated from the model agreed with measurements within 4%. The nitrogen and carbon cycling segments of the original study are near completion.

References

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