PROJECT SUMMARY

Title: Field monitoring of drainage and nitrate leaching from managed and unmanaged ecosystems

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Background/Need: The appropriate balance between profitable agricultural production and environmental degradation is challenging to maintain because of the relative ease with which potentially environmentally harmful solutes, like nitrate-nitrogen (N), move with water through soil. Over fertilization of agricultural crops with N affects nitrate-N leaching and impacts groundwater quality. In Wisconsin alone, a significant number of counties, potentially affecting more than one million people, have areas of medium to high susceptibility for groundwater nitrate-N leaching from excess applications of N fertilizers. This is a problem that plagues the majority of the states in the upper Midwest.

Objectives: The main objective of this study was to continuously monitor drainage and nitrate-N leaching from managed and unmanaged ecosystems. Specific objectives accomplished during this study were the following: 1) continuous year-around monitoring of drainage and nitrate-N leaching from pre-existing, optimally N-fertilized, no-tillage and chisel plow corn plots; 2) installation of 4 new equilibrium-tension lysimeters in pre-existing no-tillage and chisel plow corn plots that monitored drainage and nitrate leaching at a reduced level of N fertilization; 3) cation and heavy metal leaching associated with nitrate leaching were monitored; and 4) a solute transport computer model was developed and validated with field measurements.

Methods: The objectives of this study were achieved through continuous year-around field monitoring of drainage and solute leaching from undisturbed soil columns using equilibrium tension lysimeters installed in fertilized (i.e., installed Fall 1995) and unfertilized (i.e., installed Fall 1999) chisel-plowed and no-tillage corn agroecosystems and a restored prairie (i.e., installed Fall 1995). Chemical analyses for nitrate-N and ammonium-N were determined colorimetrically using a continuous-flow ion analyzer. Soluble organic carbon was determined by high-temperature catalytic combustion. Soluble potassium, calcium, magnesium, zinc, manganese, copper, iron, sodium, and aluminum were performed by inductively coupled plasma - optimal emission spectrometry. All chemical analyses were conducted on instruments operated by the State Soil and Plant Analysis Lab. The solute transport computer model subroutine was developed in Fortran language and validated against drainage and nitrate-N leaching

losses measured in the fertilized no-tillage and chisel-plowed corn agroecosystems as part of a doctoral dissertation.

Results and Discussion: Drainage generally occurred between January and June with, at times, high variability among replicate lysimeters. Between January 2000 and early January 2001, cumulative mean drainage was highest for the fertilized chisel-plowed corn agroecosystem, similar for the fertilized and unfertilized no-tillage corn agroecosystems, and lowest for the restored prairie and unfertilized chisel-plowed corn agroecosystems. Nitrate-N leaching losses were < 0.03, 3.5, 4.2, 23, and 58 kg ha^{-1} yr^{-1} in the prairie, unfertilized no-tillage, unfertilized chisel-plowed, fertilized no-tillage, and fertilized chisel-plowed corn agroecosystems, respectively. Significant cationic nutrient leaching (i.e., Ca, Mg, and Na) occurred along with nitrate-N leaching to preserve neutrality of the soil solution.

Conclusions/Implications/Recommendations: Corn crops fertilized with N at the optimum recommended rate to maximize profits from yields result in flow-weighted NO_3^--N concentrations at the bottom of corn root zones of 8.9 mgN L^{-1} and 11.7 mgN L^{-1} for chisel-plowed and no-till treatments. Significant drainage and leaching losses typically begin in January when, depending on the amount of residue cover on the soil surface, a portion of the upper soil profile is frozen. In addition, to maintain charge balance and neutrality of the soil leachate solution, an equivalent amount of positive charge must leach with each negatively charged NO_3^--N ion. Therefore, the long-term loss of soil fertility and cation exchange capacity may be a threat when nitrate-N leaching continues to occur due to N fertilization above and beyond what is required by a crop to produce a sufficient yield.

Based on the results of this study and on the information gathered in previous years prior to this study, we would recommend against Fall applications of inorganic N fertilizer or N-rich manure due to the potential for significant leaching to occur over the winter through frozen soil and in the spring of the year when the soil thaws. Because NO_3^--N concentrations are near the 10 mgN L^{-1} drinking-water standard for optimal fertilizer applications, our results suggest that excessively high ground water concentrations may be caused by excessive fertilization so that strong incentives for farmers to apply fertilizers at optimal rates (or less) should be imposed.

Related Publications:

Brye, K.R., J.M. Norman, L.G. Bundy, and S.T. Gower. 2001. Nitrogen and carbon leaching in agroecosystems and their role in denitrification potential. J. Environ. Qual. 30:58-70.

Key Words: drainage, leaching, nitrogen, nitrate, prairie, corn, no-tillage, and chisel-plowed

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