Remediation of Soil and Groundwater using Effectively and Ineffectively Nodulated Alfalfa

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Location of Research: University of Wisconsin-Stevens Point, Univ of MN St Paul and Dopp dairy farm Portage County

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Project Summary

Background:

Federal drinking water standards are exceeded for nitrate-N in 10% of the private wells in Wisconsin and over 40% in some Portage County townships. In addition, P leaching is becoming a recognized concern on soils that receive large applications of livestock manure.

This study was designed to test whether normal, N_2-fixing (effectively nodulated) alfalfa or special non-N_2-fixing (ineffectively nodulted) alfalfa can remove excess N and P from an abandoned barnyard. Nutrient removal, yield, and persistence of these plants will help determine the feasibility of their use in this and other agricultural activities in medium-to-coarse textured soils common to Wisconsin and other Midwest states.

Objective:

The primary **objective** of this study was to monitor changes that occur in groundwater quality and soil fertility in an abandoned barnyard planted with effectively and ineffectively nodulated alfalfa cultivars (Agate and Saranac) for possible use in phytoremediation This project consists of several components; Variables analyzed included groundwater chemistry, soil characteristics, and differences between alfalfa cultivars for yield and plant nutrient content.

Methods:

Groundwater monitoring wells (up- and down-gradient) of the 60 m-long plots were sampled monthly through the growing season, from March through October, plus a winter sampling, totaling nine sample dates per year. Analyses included NO_2+NO_3-N and Cl- on all sample dates plus two samples per year for total reactive P, K, and NH_4-N.

Spatially-referenced samples from the upper 1.5 m of soil were collected at the end of each growing season in 1998 and 2000 for analysis of NO_2+NO_3-N, NH_4-N, and extractable P. Spatially-referenced topsoil samples were obtained in spring of each year and analyzed for inorganic N and extractable P. Eight spatially-referenced herbage samples were collected from each plot every harvest for determination of biomass and N and P content. Topsoil samples taken at the same locations were analyzed for inorganic N and extractable P.

Results:

Both Agate and Saranac cultivars of alfalfa are capable of taking up as much as 400 kg/ha of N from these sandy soils. The maximum uptake was 380 kg/ha by effective Agate in 1999, whereas Ineffective Agate removed 250 kg/ha. Yield and N uptake were reduced in 2000 and 2001 due to drier conditions.

This research demonstrates that N_2 fixation uptake is facultative with less fixation occurring when N supply is large. Ineffective cultivars did not remove as much total N as their effective pairs, because available N was rapidly leached in these soils, limiting growth and yield of the non-N_2-fixing alfalfas.

Nitrate leaching to ground water was very significant with all down-gradient wells exceeding the 10 mg/L nitrate-N standard. Values as high as 88 mg/L were found in the down-gradient wells in 2002. The average nitrate-N concentrations in the upper 1.8 m of the water table down-gradient of the plots in 2001 was 47 mg/L. This concentration of N would amount is equivalent to about 250 kg/ha in the upper 1.8 meters of the aquifer. We did not find any evidence of significant groundwater impacts from P, ammonium N or K in this study, but P leaching was apparent in the upper soil profile.

Conclusions and Recommendations:

This research has shown that in sites with sandy soils and groundwater recharge of approximately 25 cm per year that leaching of N from cultivated barnyard soils is more rapid than is the establishment and N uptake alfalfa.

Further research to optimize N uptake in remediation projects should focus of companion crops to alfalfa that would provide more rapid uptake of N during alfalfa establishment. Direct seeding techniques that would not require cultivation should be used to minimize oxidation of organic N compounds. Cultivation results in the destruction of any compacted layer, which in turn, encourages both rapid mineralizaton of organic N and leaching. Cultivation may be unavoidable, however, if compaction is too high to allow rapid root elongation.

Key Words: phytoremediation, nitrate leaching, ineffective alfalfa, groundwater nitrate, nitrogen fixation

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