Crop Rotations Effects on Leaching Potential and Groundwater Quality

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by
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BACKGROUND / NEED

There is an increasing concern about the effect of farming on ground water quality. Leaching of surface-applied chemicals is effected by the amount of water percolating through it. There is a need to study the movement of water through the soil. Most of the past research on solute movement in Wisconsin has focused on areas planted continuously with corn with irrigation on coarse-textured sandy soils. Very little information is available on water and solute movement under natural rainfall conditions in the more common, medium-textured (silt loam) soils of Wisconsin.

OBJECTIVES

1) To determine solute and water percolation transit times to shallow groundwater on Griswold silt loam soil in southeastern Wisconsin, near Elkhorn. 2) Determine the relative importance of piston vs. macropore flow in a prairie-derived silt loam soil.

METHODS

Leaching Frame Study: In the summer of 1990, a preliminary leaching frame study was conducted to study how fast the water and solutes move through bare soil. Two artificial rainfall treatments, each applying 4 inches/month either in biweekly "showers" (treatment 1) or fortnightly "storms" (treatment 2) were compared to natural rainfall (treatment 3). It was hypothesized that if piston flow dominated, the depth of the bromide tracer would be a function of the amount of percolation and treatment 1 would equal treatment 2. On the other hand, if macropore and preferential flow dominated, there would not be a bromide peak, and more of the incoming water would bypass the soil matrix during treatment 2 than during treatment 1. It was anticipated that bromide would leach farther in treatment 1 than treatment 2.

The three treatments were applied to 1m x 1m leaching frames. A drop-forming rainfall simulator, was used to simulate the artificial rainfall regimes. Potassium bromide (Kbr^-) salt was applied in water to each of the nine leaching frames. Soil samples were taken in June, August, and November of 1990 to determine the bromide distribution in the soil profile.

Crop Rotation Study: Five rotations were compared in this study, which was initiated in the spring of 1991. The rotations were: R1-continuous corn, R2-Soybean-corn, R3-Soybean/wheat-wheat/red clover-corn, R4-Alfalfa-alfalfa-alfalfa-corn, and R5-Oats/alfalfa-alfalfa-corn. One monitoring well was installed in the first phase of each of the rotations. Br^- tracer was surface-applied to a 5 m x 5 m subplot surrounding the monitoring well. Water samples collected in December 1991, May 1992, and December 1992 were analyzed for Br^-, nitrate and atrazine. Soils were sampled twice during 1991 and once in 1992 to determine the Br^- distribution in the soil profile.

RESULTS

Leaching Frame Study: Bromide was found up to 1 m depth under all the three treatments by August. Approximately, 8-15% of the applied Br^- was lost beyond 1 m depth under the artificial rainfall treatments while all the Br^- was recovered under the natural rainfall treatment. The lack of a peak bromide concentration in any of the profiles indicated that preferential flow was the dominant leaching pathway in all three treatments.

Crop Rotation Study - Soil Analyses: By August 1991, detectable amounts of Br^- were found up to 80 cm deep in the soil under all the crops. Br^- was concentrated in the top 20 cm of the soil profile. By November, however, Br^- concentration had decreased markedly in the top 20 cm. Heavy postseason rainfall occurred in September and October. Little change in Br^- content was observed over the winter. High variation in Br^- concentration by depth was observed at all the three sampling dates. Field observations did not agree with piston-type simulations of GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), which predicted that Br^- would move to 60 cm depth by November 5, 1991 under corn. Br^- was detected at 80 cm depth by August, 13 under all the crops.

Crop Rotation Study - Groundwater Analysis Bromide was detected within five months after application in all monitoring wells. Bromide concentrations decreased over time in all the five treatments. When analyzed by the Immuno Assay Method, atrazine levels in the ground water were below the Enforcement Standard of 3.5 ppb in all monitoring wells. However, when analyzed by the Gas Chromatography method for atrazine metabolites, 12 out of 20 wells exceeded the Enforcement Standard. Nitrite+Nitrate concentrations were above 45 ppm in six wells in May 91, and in three wells in December 1991 and April 1992 and only one well in December 1992.

CONCLUSIONS

It can be concluded from the Leaching Frame and Crop Rotation studies that macropore flow is the dominant mechanism of downward movement of water and salts even under natural field conditions. Surface-applied chemicals could reach the groundwater within one growing season under these conditions.

IMPLICATIONS / RECOMMENDATIONS

Bromide represents a worst case scenario since it moves slightly faster than water and is not altered by any microbial activities. Nevertheless, the speed of movement under field conditions, regardless of crop rotation, suggests that designing good management systems for chemical use on silt loam soils over shallow groundwater will be difficult.

RELATED PUBLICATIONS

Using Bromide to Study Water Movement Through a Prairie Derived Silt Loam Soil in Wisconsin T.K. Iragavarapu, J.L.Posner, G.D. Bubenzer. Agronomy Abstracts 1991 Annual Meetings pp 333.

Using Bromide to Study Water Percolation and Solute Trans times under different crops. T. K. Iragavarapu, J. L. Posner, and G. D. Bubenzer Agronomy Abstracts 1992 Annual Meetings pp. 327.

Study of Water and Solute Movement Through Soil Under Natural Field Conditions. T. K. Iragavarapu, J. L. Posner, and G. D. Bubenzer Agricultural Research To Protect Water Quality of the Soil and Water Conservation Society Abstracts 1993 (February 21-24) pp. 36.