Column Leaching Study of Six Pesticides, Nitrate, and Chloride Through Four Wisconsin Soils

Project Number DNR-55
by
Byron Shaw, Prof. Soil and Water Science, UW - Stevens Point , Mike Heitman, Research Assistant, UW - Stevens Point

Contract: July 1, 1989 through June 30, 1991
Funding: Wisconsin Department of Natural Resources (DNR) and UWSP - Environmental Task Force
Focus Area: Pesticides
Key Words: aldicarb, oxymyl, carbofuran, carbaryl, atrazine, alachlor, nitrate, chloride

BACKGROUND/NEED

The leaching of pesticides to groundwater from agricultural practices has been of increasing concern throughout the United States. Differences in chemical solubility, adsorptive characteristics, volatility, and degradability as well as soil properties that effect water movement, biological activity and chemical retention all affect the amount of a pesticide that will leach to groundwater. Detections of pesticides in groundwater at concentrations above groundwater standards indicate that groundwater has been impacted. In order to prevent pesticide migration to groundwater, an understanding of the processes that cause pesticide migrations needs to be evaluated and understood.

OBJECTIVES

To compare the leachability of six pesticides (oxamyl, aldicarb, carbofuran, carbaryl, atrazine and alachlor) and two inorganic tracers (potassium chloride and ammonium nitrate) through the root zone (upper 1 meter) of four soils commonly used for agriculture in Wisconsin under uniform conditions.

METHODS

The soils studied included two sandy outwash soils (Sparta and Plainfield sands), one silt loam over sand (Antigo), and one sandy loam (Burkart). The pesticides in this study included aldicarb, oxymyl, carbofuran, carbaryl, atrazine, and alachlor. In addition, ammonium nitrate and potassium chloride were added to compare the pesticide leaching to nitrate and chloride movement. Two rates of chemical addition were used representing the normal range of chemical applications for each pesticide.

Soil used within the columns were collected from soil pits at locations where there had been no pesticide application within five years of the date of sampling. Each soil horizon was sampled from the walls of the soil pits. The soil collected was air dried and stored in a dry place until needed. Four columns each were packed with Antigo silt loam, Burkart, Sparta, and Plainfield sand soils. The Plainfield and Sparta are considered sandy soils and the Burkart and Antigo soil are more clayey.

The pesticides were chosen to cover the range of expected mobility and to include compounds of current concern, due to their detection in groundwater (atrazine and aldicarb). The inorganic tracers were selected based on their current use as fertilizer in Wisconsin agriculture.

Field anomalies such as macropore transport, presence of cobbles, below average rainfall, erosion, plant uptake, and naturally occurring zones of preferential flow (fingering) were controlled to prevent skewing the leaching results. By conducting a column leaching study under uniform conditions the results could be used for strict comparison purposes, without the occurrence of outlier data points.

Application rates for pesticides were obtained from instructions provided by the manufacturers. Potassium nitrate and ammonium nitrate were applied at a rate of 300 lbs/acre. Chemical applications were completed by pouring

prepared solutions uniformly over the surface area of the soil column. A four-inch layer of clean, well-sorted sand was then applied to each column to disperse the simulated rainwater. All soils had 11.6 inches of distilled water added over a seven week leaching period.

RESULTS/DISCUSSION

Results showed more rapid leaching of pesticides, nitrate, and chloride through the sandy Sparta and Plainfield soils. Only small amounts of pesticides were recovered in the leachate from the Antigo or Burkart soils. Only about 70 percent of the field moisture capacity of the finer soil columns was collected as leachate, compared to 200 percent from the sandy soils. Thirty to 48 percent of the highly soluble chemicals (aldicarb, oxamyl, and carbofuran) were found in the leachate from the sandy soils. Carbaryl was not found in detectable amounts in any leachate. Atrazine and alachlor amounts in leachate from the sandy soils were 2 percent and 0.2 percent, respectively. Aldicarb sulfoxide was the primary form of aldicarb found and leached at about the same rate as oxamyl and chloride. Carbofuran appeared to move slightly slower, as did nitrate.

Soil residues in the sandy soils showed fairly complete leaching of the soluble pesticides, with atrazine residues the highest of any pesticide in the Plainfield soil. Residues in the Antigo and Burkart soil showed relatively large amounts of aldicarb, carbofuran, and atrazine remaining at the end of the seven week study. Carbaryl and alachlor were in very low amounts, as was oxamyl in the Burkart soil. Significant oxamyl was found in the more acid Antigo soil.

CONCLUSIONS/IMPLICATIONS/RECOMMENDATIONS

Aldicarb, oxamyl, and carbofuran are highly leachable in Wisconsin's sandy soils. These chemicals move fairly easily to lower depths in coarse textured soils. There was no significant difference between the leaching results observed between the Plainfield and Sparta soils. Atrazine, while moving slower than the highly leachable pesticides, was found in the leachate from the sands at concentrations above current standards. Alachlor leaching was found to occur, but in generally small and erratic amounts. Carbaryl did not appear to move significantly in any of the soils studied. The pesticide retention time within the soil was relative to the water solubility and adsorption characteristics of the chemical. Under similar conditions, chloride leached at a slightly faster rate than nitrate. Within the range of manufacturers recommendations, increasing the application rate of pesticides does not influence the rate of leaching, but does increase the concentrations leached.