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Nitrate and Pesticide Losses Under Various Cropping Management Systems

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ABSTRACT

The objective of this study was to evaluate the effectiveness of tillage and cropping management systems in reducing the movement of nitrate and pesticides in surface and sub-surface flow. Nitrate and pesticides in runoff and sub-surface tile flow have been monitored for two years from fields with various tillage and cropping management practices. Samples have also been obtained along the mainstream of the watershed.

Concentrations of nitrate and pesticides differed little among specific sampling locations along the river, but they definitely followed a seasonal cycle. Nitrate concentrations from the tile drains varied considerably between fields depending upon the cropping management systems used, with concentrations varying seasonally as in the river.

Key Words: Nitrates, Pesticides, Cropping Systems, Water Quality

INTRODUCTION

The overall goal of the Little Vermilion River Agricultural Nonpoint Source Hydrologic Unit Area Project is to reduce the levels of nitrate and pesticides entering Georgetown Lake. To accomplish this goal, the Cooperative Extension Service (CES), Soil Conservation Service (SCS), and Agricultural Stabilization and Conservation Service (ASCS) are encouraging the adoption of integrated crop management (ICM) practices throughout the watershed. Besides helping improve the quality of water in the lake, these practices should also help maintain good water quality in aquifers that serve private wells.

The objective of this research is to determine if selected management practices can eliminate, reduce, or retard the movement of agrichemicals to ground water and streams. Studies are being conducted in the Little Vermilion River Watershed on several fields that have various practices, including fertilizer and pesticide management systems, buffer strips and wetlands.

PROCEDURES

The Little Vermilion River Agricultural Nonpoint Source Hydrologic Unit Area is located in East Central Illinois and includes 48,900 hectares in parts of Vermilion, Champaign, and Edgar counties. Monitoring river quality and sub-surface drain tile flow and water quality has been conducted at river locations and at the outlet of sub-surface drainage systems from six management systems.

Management Systems

Six small sub-surface drainage systems were selected with the help of SCS and CES field personnel (Table 1). The watersheds have a systematic sub-surface drainage system with exact extent of drainage known.

Four tile drainage monitoring sites were installed in 1991. At one location where soils are predominately Sabina silt loam and Xenia silt loam, a 7.5 ha sub-surface drainage system is under no-till row crop management. This field is named No-Till Corn-Beans because the cropping pattern is alternately corn and soybeans. A second 6.9 ha. sub-surface drainage system outlets from a field in permanent grass, and is named Continuous Meadow.

The soils are predominately Flanagan silt loam and Drummer silty clay loam at another location containing two sub-surface drainage systems of approximately 1.5 and 2.7 ha. Both are in a reduced-till row-crop management system with one field in corn and the other in soybeans and alternating each year. These fields have been designated R-Till Corn-Beans and R-Till Beans-Corn.

Two drainage sites on predominately Flanagan silt loam and Drummer silty clay loam soils were installed in 1992. One site is a 13.1 ha sub-surface drainage system under a corn-soybean conventional tillage management system, and is named C-Till Beans-Corn. The second site, designated Seed Corn, has a 2.8 ha sub-surface drainage system where high-nitrogen conventional-till seed corn management is alternated with soybeans.

Sub-surface drainage (tile) flow is sampled bi-weekly and additional samples are taken during increased flow following major rainfall events. These samples are analyzed for nitrate and pesticides. The sub-surface outflow depth is monitored continuously with a flume and stage recorder.

Records of agrichemical application to and tillage on the monitored fields are maintained (Table 1). Soil sampling is accomplished to provide background and periodic concentration of agrichemicals in the field soil. Measured flow depths with time are used to compute flow rate and volume. Computed volumes of sub-surface flow with measured concentrations of nitrate and pesticides in the flows will provide information to determine total agrichemical loss in flows.

River

Seven sampling points were established along the Little Vermilion River, including Georgetown Lake. Water samples are collected at intervals following rainfall events and during baseflow. Water was analyzed for nitrate and four pesticides--trifluralin, atrazine, alachlor, and metolachlor. These pesticides are the most heavily used soil-applied herbicides in the Corn Belt and represent chemicals used on corn and soybeans.

RESULTS AND DISCUSSION

Results of nitrate determinations are shown in Figures 1 and 2 for the six river and one lake sampling stations. During April, May, and June, 1991, all water samples contained nitrate-N at concentrations exceeding the U.S. EPA Health Advisory Level of 10 mg/L NO_3-N. By July, 1991, however, nitrates dropped below the 10 mg/L threshold. Nitrate levels rose somewhat during November and December and returned to greater than 10 mg/L during March through April, 1992. Nitrate-N concentrations again dropped at most locations, and were generally below the 10 mg/L threshold at all locations except the most upstream station (county line), until February, 1993, except for a rise in July, 1992, at most stations. The February, 1993, rise to slightly above and below 10 mg/L at the county line station (30 km above dam) through May, 1993, is less than the peak amounts the previous two years.

Atrazine was detected in nearly every sample of water from the river and lake (Figures 3 and 4). On May 15 and July 10, 1991; July 3, and October 7, 1992; and April 14, 1993, atrazine concentrations spiked considerably greater than the 4 ppb scale of Figures 3 and 4 at several locations to maximum concentrations of 25.3 ppb, 10.1 ppb, 19.5 ppb, 7.1 ppb and 11.9 ppb, respectively. Rainfall at the Urbana, IL gage was 37 mm, 34 mm, and 53 mm, respectively, for the first three events and 66 mm for the last event, but no rainfall was associated with the October 7, 1992, spike. It is evident from the expanded concentration scales of Figures 3 and 4 that atrazine concentrations have risen and fallen in a pattern similar to nitrate-N (Figures 1 and 2). The peak concentrations of atrazine of 17 ppb at the sampling location 5.6 km upstream of the dam and of 25 ppb in the lake on May 15, 1991; and of 6.9 ppb, 7.0 ppb, and 7.9 ppb at 5.6 km upstream of the dam, in the lake and below the dam, respectively, on April 14, 1993, do not show in Figure 4 because of the expanded atrazine concentration scale. Atrazine concentrations were above the EPA Health Advisory Level of 3 ppb on ten occasions in the river but only three times in the lake.

Alachlor and metolachlor concentrations were detected on 15 occasions and, then, not at each sampling point. Alachlor was detected three times in the lake and metolachlor was detected twice. Trifluralin was detected on 11 occasions in the river, most of those at the upstream stations. It was detected three times in the lake at concentrations below 0.5 ppb, the practical detection level.

Results of the nitrate concentrations for the four tile monitoring stations are presented in Figure 5. Nitrate-N concentrations were above the 10 mg/L levels at all sampling times from the Reduced Till (R-Till) and Seed Corn locations and much of the time from the Conventional Till (C-Till) and No-till locations, but below that level from the Continuous Meadow location (Figure 5). As expected, the seasonal pattern of nitrate-N concentrations from the tile stations is similar to, but less pronounced than that found in the river (Figure 1); after all, the tile systems supply the river flow. However, it is well to note that the scales of nitrate-N concentration of Figures 1 and 5 are quite different, with the concentrations in the river about half that of the maximum tile outlets. Either dilution by other low nitrate flows or denitrification or both are occurring.

It seems clear that the amount of chemical fertilization and, also, the time of application of that fertilizer affects the nitrate-N concentrations from field tile. The greatest concentrations are from R-Till Corn-Beans, R-Till Beans-Corn and Seed Corn fields where 268 Kg/ha - Nitrogen, 272 kg/ha - Nitrogen and 242 kg/ha - Nitrogen, respectively, were applied. These three cropping systems had mean nitrate - N concentrations and standard deviations over the period of record of 19.5 mg/l and 5.5 mg/l; 16.2 mg/l and 3.1 mg/l; and 17.2 mg/l and 4.0 mg/l, respectively, for an overall mean concentration of 17.7 mg/l for the pre-plant application systems. Lower Nitrate - N concentrations were observed from C-Till Beans-Corn and No-Till Corn-Beans where 232 kg/ha - Nitrogen and 188 kg/ha - Nitrogen, respectively were applied. These cropping systems had mean nitrate - N concentrations and standard deviations over the period of record of 9.5 mg/l and 1.5 mg/l; and 10.3 mg/l and 2.6 mg/l, respectively, for an overall mean concentration of 9.7 mg/l. Both of those lower concentrations were from fields where nitrogen was applied to corn as a side dress application one month after planting when the corn can best utilize the nitrogen. The mean nitrate - N concentration for the continuous meadow field was 1.4 mg/l with a standard deviation of 1.3 mg/l. Obviously, the pre-plant application treatment means are significantly different from the side-dress application treatment means with an overall difference between the treatments of 8.0 mg/l nitrate - N.

The apparent decrease in nitrate - N concentrations are probably due to a change in rainfall patterns over the three years. The detailed analysis of nitrogen loss with rainfall and crop growth has not yet been accomplished.

Atrazine concentrations from the tile stations are presented in Figure 6, except for four peaks of 9.6 ppb, 6.4 ppb, 4.3 ppb at the No-Till Bean-Corn station and 4.7 ppb at the C-Till Beans-Corn station on July 7, October 20, November 3, 1992 and January 4, 1993, respectively. The atrazine concentrations from tile station outlets seem to be very similar to those collected from river samples.

Alachlor and metolachlor concentrations were detected on 20 occasions, and trifluralin was detected on 19 occasions, but detailed inspection of the loss of pesticides with rainfall events will be a subject for future study.

SUMMARY AND CONCLUSIONS

The objective of this study was to evaluate the effectiveness of tillage and cropping management systems in reducing the movement of nitrate and pesticides in surface and sub-surface flow. Nitrate and pesticides in sub-surface tile flow have been monitored for two years from fields with various tillage and cropping management practices. Samples have also been obtained along the mainstreams of the watershed.

Concentrations of nitrate and pesticides differed little among specific sampling locations along the river, but they definitely followed a seasonal cycle. Nitrate concentrations from tile drains varied considerably between fields depending upon the cropping management systems used, with concentrations varying seasonally as in the river.

The effect of the application of large amounts of nitrogen fertilizer, particularly as a pre-plant operation, is clearly shown in the nitrate - N concentrations from tile drains. The pre-plant anhydrous - N application systems with average Nitrogen application of 261 kg/ha had a mean concentration of nitrate-N of 17.7 mg/l while the side-dress application systems with average Nitrogen application of 210 kg/ha had a mean concentration of nitrate-N of 9.7 mg/l. The mean concentration of nitrate -N from a permanent meadow field was 1.4 mg/l.

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Table 1. Tile Monitoring Site Characteristics and Management Practices.

Descriptor	Field Name					
	R-Till Corn-Beans	R-Till Beans-Corn	No-Till Corn-Beans	Continuous Meadow	Seed Corn	C-Till Beans-Corn
Area Drained	2.7 ha.	1.5 ha.	7.5 ha.	6.9 ha.	2.8 ha.	13.1 ha.
Soils	Drummer and Flanagan sl		Sabina and Xenia sl		Drummer and Flanagan sl	
1990 Fall Fertilization	460 kg/ha. of 10-27-18	168 kg/ha. of 4-11-37				448 kg/ha. of 3-9-39
Tillage	Chisel	Chisel, Disc			Chisel	Moldboard
1991 Tillage	Field Cult.	Field Cult.			Disc, Field Cult.	Field Cult.
Crop	Corn	Soybeans	Corn	Grass	Soybeans	Soybeans
Fertilization	222 kg/ha. - N anhydrous		336 kg/ha. of 6-15-40 168 kg/ha. - N side dress			
Pesticides	Extrazine	Lasso Pinnacle	Extrazine 2, 4 - D		Treflan, Command Basagran	Sonolan Classic/Pinnacle
Yield	10.73 Mg/ha.	3.27 Mg/ha.	NA		2.98 Mg/ha.	NA
Fertilization		458 kg/ha. of 8-20-27			360 kg/ha. of 9-23-30	560 kg/ha. of 3-9-39
Tillage	Disc	Chisel				
1992 Tillage	Field Cult.	Field Cult.			Field Cult.	Field Cult.
Crop	Soybeans	Corn	Soybeans	Grass	Seed Corn	Corn
Fertilization		229 kg/ha. - N anhydrous	225 kg/ha. of 0-0-60		192 kg/ha. - N anhydrous	202 kg/ha. - N side dress
Pesticides	Prowl	Extrazine	2-4-D, Pursuit Roundup		Sutan Atrazine	Bicep
Yield	3.39 Mg/ha.	12.42 Mg/ha.	2.89 Mg/ha.		2.26 Mg/ha.	13.30 Mg/ha.

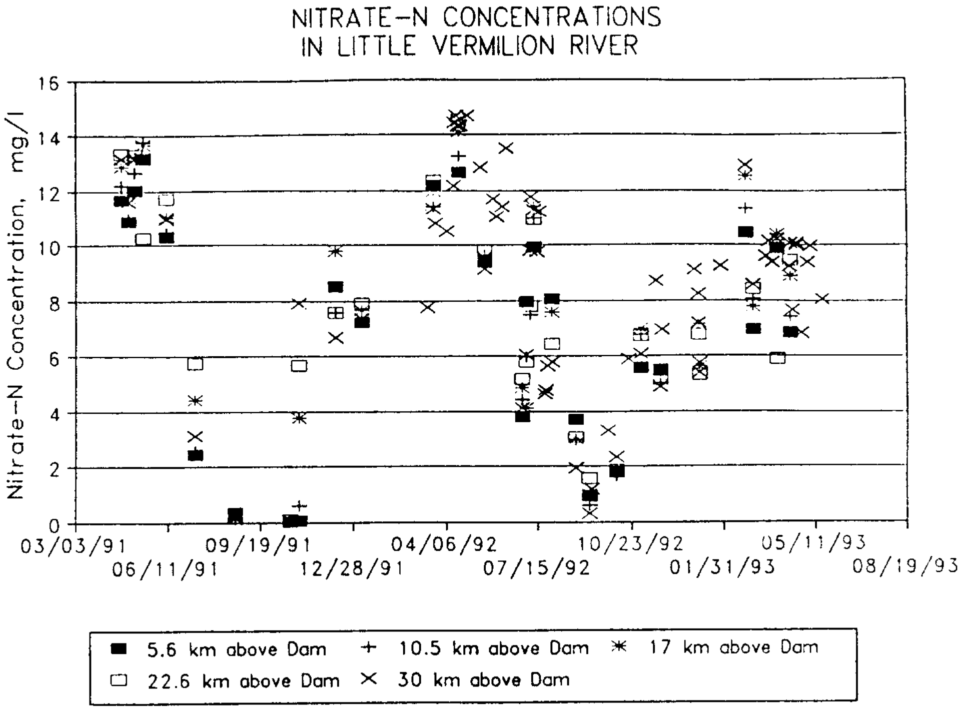

Figure 1. Nitrate-N concentrations at Little Vermilion River locations.

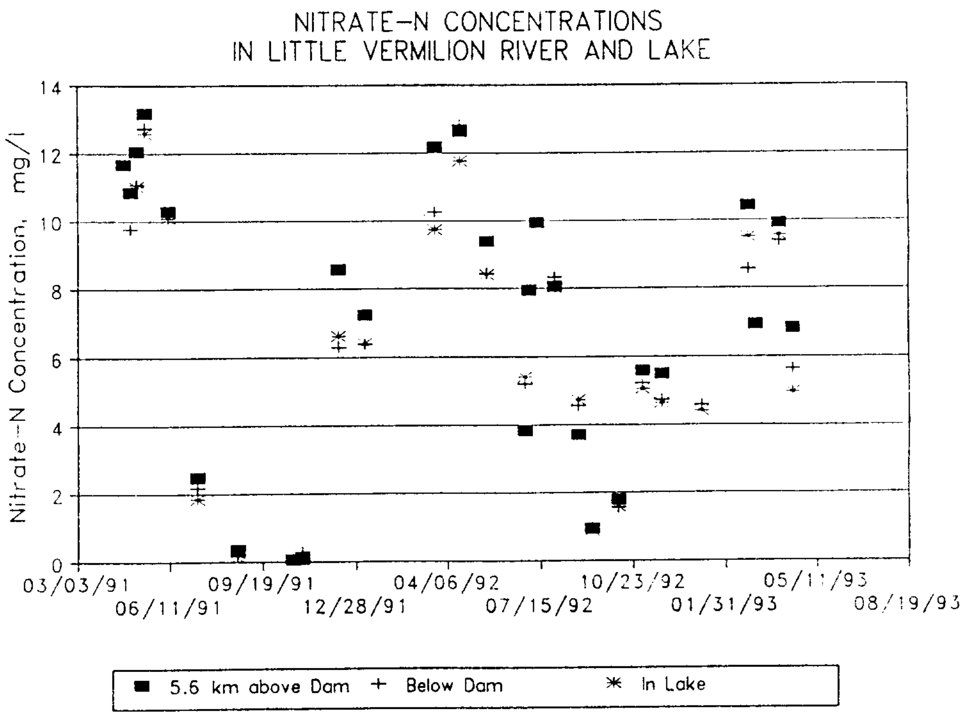

Figure 2. Nitrate-N concentrations in Georgetown Lake and up- and downstream of the lake in the Little Vermilion River.

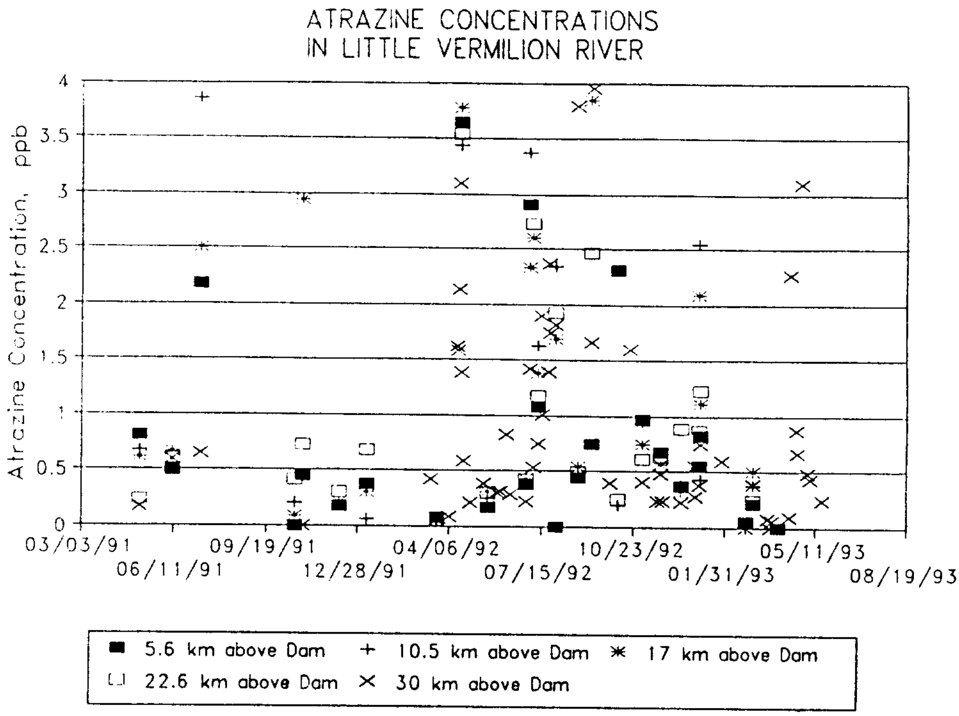

Figure 3. Atrazine concentrations at Little Vermilion River locations.

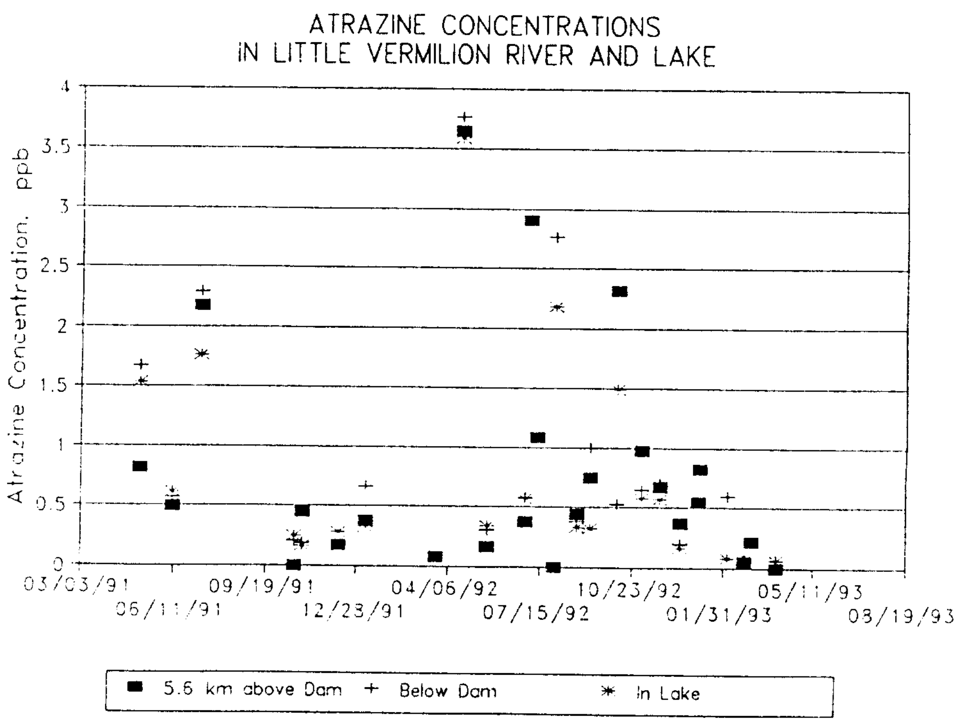

Figure 4. Atrazine concentrations in Georgetown Lake and up- and downstream of the lake in the Little Vermillion River.

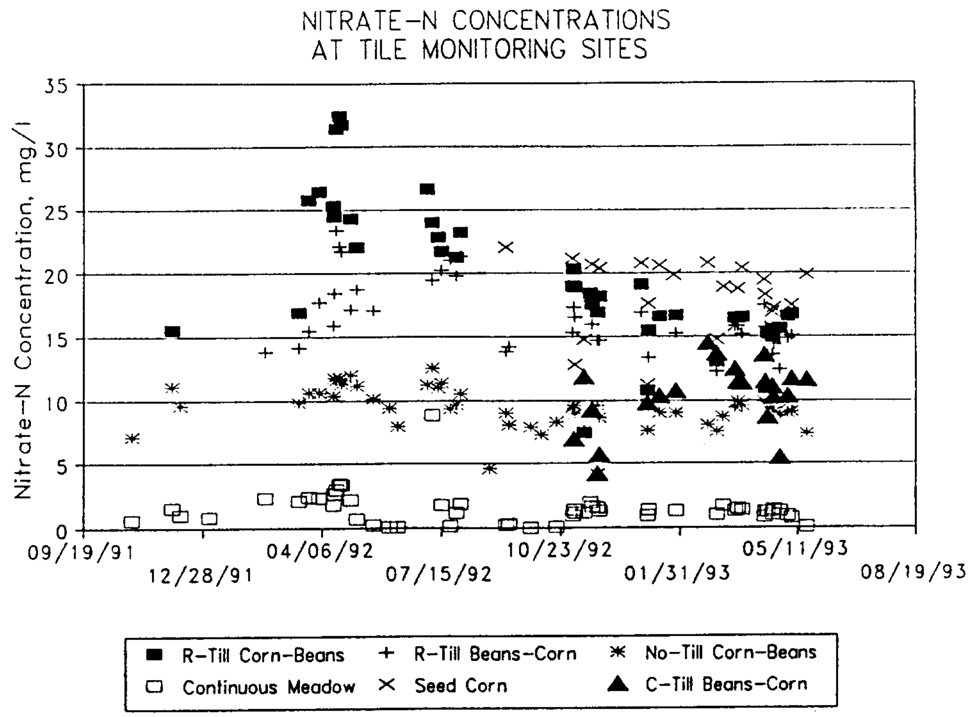

Figure 5. Nitrate-N concentrations at six tile monitoring sites.

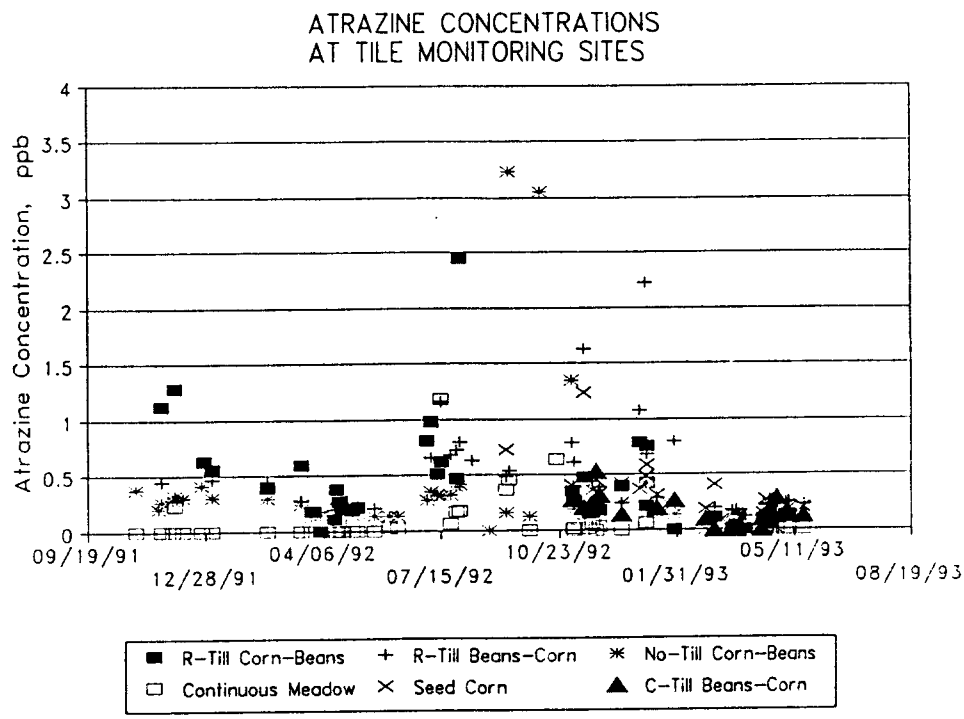

Figure 6. Atrazine concentrations at six tile monitoring sites.