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Duluth MN 55804

Research and Development

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Project Summary

Insect Interlaboratory Toxicity Test Comparison Study for the Chironomid *(Paratanytarsus sp.)* Procedure

Armond E. Lemke and Richard L. Anderson

A test method guideline for the chironomid *Paratanytarsus sp.* was evaluated. Six laboratories participated in the interlaboratory comparison study. Three items were compared, including start-up and maintenance of a rearing colony, a 48-hr acute test, and a 28-day life history chronic. All participating laboratories were able to start and maintain the rearing colonies. Chemicals used for testing were trichlorophenol and acenaphthene. Forty out of an expected total of 48 test results were reported.

The 17% failure rate appeared to be related to the volatility of the chemical in the acute tests and to an unexplained test water problem at specific laboratories in the chronic tests. All participants recommended that the preparation of a set of forms for recording data and training rather than more detail in the guidelines would improve testing efficiency.

This Project Summary was developed by EPA's Environmental Research Laboratory, Duluth, MN, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The use of single species toxicity tests for environmental protection relies on the availability of test methods using organisms from a wide range of trophic levels Chironomids, a ubiquitous group of non-biting mosquito-like flies, are representative of one of these levels. Test methods must be evaluated for completeness, understanding, and scientific quality. This study reports the results of six laboratory intercomparison test sets for methods for rearing, acute testing and chronic testing for the parthenogenetic midge *Paratanytarsus sp.*

Methods and Materials

The participating laboratories were chosen for experience in toxicity testing, not necessarily with midges.

All principal investigators were given a demonstration of operational techniques, a set of guidelines, eggs to start a colony, and the test chemicals, reagent grade trichlorophenol and acenaphthene. All participants were asked to follow the supplied guidelines and conduct two tests (an *acute and chronic exposure*) with each chemical and each method. Each laboratory was asked to report LC50 values for the acute test and effect/no effect levels for the chronic tests. Each laboratory was also asked to report any problems with conducting the tests and reading or interpreting the methods

Results and Conclusions

All laboratories were able to start and maintain rearing colonies of the insect. Forty tests, 83% of the 48 expected, were reported. Four acute tests, all with acenaphthene and four chronic tests, two with each chemical, were reported as failures. The lack of success was linked to chemical problems (volatilization) in the acute tests and an unsolved water supply problem in the chronic tests. The ranges for reported LC50 in the acutes were: acenaphthene, test 1, 2.00 to 0.06 mg/l; test 2, 2.09 to .07 mg/l; trichlorophenol, test 1, 43 to 3.7 mg/l; test 2, 65.1 to 2.5 mg/l. Factors which were thought to contribute to the wide range were loss of chemical, delay in analysis of chemical, and inadvertent use of a more sensitive instar. Chronic results reported as the geometric mean of the effect/no effect level were: acenaphthene, test 1, .91 to .014; test 2, .49 to .024; trichlorophenol, test 1, 5.0 to .31; test 2, >10 to .38. Various factors including food supply, turnover rate, and loss of chemical from the test chambers appeared to be associated with variation in results. All participants regarded additional experience/training and a standard form for required data as more essential to narrowing this range than greater detail in the guidelines.

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*The complete report, entitled "Insect-Interlaboratory Toxicity Test Comparison Study for the Chironomid (*Paratanytarsus *sp.) Procedure," (Order No. PB 84-180 025; Cost: $7.00, subject to change) will be available only from:*

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Research and Development

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Project Summary

Field-to-Stream Transport of Agricultural Chemicals and Sediment in an Iowa Watershed: Part II. Data Base for Model Testing (1979 - 1980)

H.P. Johnson and J.L. Baker

In a continuation of a previous project, data were collected on the field-to-stream transport of sediment, nutrients, and pesticides in an agricultural watershed. These data contribute to an improved qualitative understanding of the field-to-stream processes involved and provide a quantitative base for testing mathematical models that predict hydrology, erosion, and sediment and chemical transport.

During the study reported here (1979-1980), data were collected for small corn, soybean and pasture fields; for two larger mixed-cover sub-watersheds; and at three drainage stream sites. In 1979, annual rainfall (1009 mm) was well above the long-term average (823 mm), with several intense rainstorms occurring in June and July. As a result, stream flow (445 mm) was more than twice the normal amount, and sediment losses from the row-crop field sites were very high (average of 63.3 t/ha). Soil loss from the watershed as a whole was 7.6 t/ha in 1979. In 1980, precipitation (744 mm) and stream flow (182 mm) were slightly below normal; soil loss from the watershed was 3.8 t/ha. In December 1979, P was fall-applied in the field sites without incorporation; as a result, PO_4-P concentrations in snowmelt and rainfall-runoff were over 1 mg/L until the fertilizer was soil-incorporated using tillage.

Flow from the watershed was roughly half subsurface flow and half surface runoff, with about half of the surface runoff being snowmelt. During extended high flows between surface runoff events, in-stream NO_3-N concentrations were high and very similar to those in flow from shallow subsurface tile drains. The percentage of stream flow derived from subsurface drainage could be estimated, at any given time, from knowledge of NO_3-N concentrations in in-stream, surface and subsurface flow. NO_3-N losses from the whole watershed in stream flow averaged 25 kg/ha, equal to 28% of the N applied as fertilizer.

The severe runoff-erosion events in 1979 resulted in field runoff losses of herbicide as high as 7.2% (for metribuzin) most of which was associated with the water phase for the four herbicides studied (alachlor, propachlor, cyanazine, and metribuzin). The maximum loss from the whole watershed in 1979 was 2.0% (for metribuzin). In 1980, the maximum field loss was 2.8% (for cyanazine); for the whole watershed, maximum loss was 1.9% (for alachlor).

This Project Summary was developed by EPA's Environmental Research Laboratory, Athens, GA, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

In an effort to achieve national water quality goals, water pollution control activities have been directed increasingly at agricultural nonpoint sources. This resulted from the knowledge that control of point municipal and industrial sources alone would not allow the goals to be reached, particularly in predominantly agricultural areas such as Iowa. In addition, the increasing role of agriculture in our national economy and international trade has resulted in more intensive agricultural management to increase production. Consequently, more land, which is usually less suitable for cropping because of poor soils or higher slopes, is being put into production. Also, chemical inputs are being increased to produce higher yields on currently cropped land.

The study watershed illustrates these last two factors. Between 1970 and 1980, the percentage of the study watershed in row-crops increased from 55 to 80%; land in pasture, hay, grass, oats, government set-aside, and wood lots was reduced. Herbicides were applied to 40% of the watershed in 1970 and to 80% in 1980; nitrogen fertilizer use increased 2.3 times in this period, due to the increased area of row-crops, increased percentage of row-crop area treated, and increased application rates.

Although increased erosion and agricultural chemical losses are unintended side effects of the highly productive agricultural systems, research has demonstrated that management practices can be used to help control these undesirable effects. The concept of Best Management Practices (BMPs) was developed as the primary means of controlling agricultural nonpoint sources of pollution. These practices are to be effective and technically feasible, and socially and economically acceptable. Practices such as the use of conservation tillage and the installation of terraces and grassed waterways decrease sediment loss and sediment associated pollutants. Others, such as soil incorporation of chemicals, decrease chemical interaction with overland flow and thereby decrease chemical concentrations and losses in surface runoff.

It is neither physically nor economically practical to field test every potential BMP for all agricultural chemicals and for all possible combinations of weather and field conditions. Therefore, work has been undertaken to develop mathematical models (from knowledge of physical and chemical processes) that are capable of predicting BMP effectiveness for different sets of conditions. In the development of these models, transport processes in the field and possible chemical transformations and their impact on concentrations and losses must be understood. In addition, once a model has been developed, field data are necessary to test its validity.

In 1976, Iowa State University began the collection of field data in the Four Mile Creek watershed in Tama County, Iowa. Results for 1976 through 1978 were presented in a report entitled "Field-to-Stream Transport of Agricultural Chemicals and Sediment in an Iowa Watershed, Part I: Data Base for Modeling (1976-1978)," EPA-600/3-82-032. This report (Part II) presents the 1979 and 1980 field data on runoff and sediment and chemical losses for three small, single cover fields (including soil sampling data); two mixed cover, intra-basin sub-watersheds; and three stream stations. Watershed inventory and weather data are included, together with data on sediment sizes, sediment deposition, and the stream channel as a sediment source

As a culmination of this project, a national conference was held in Ames, Iowa, in 1981 to gather and disseminate information on the state-of-the-art with respect to agricultural nonpoint source pollution problems and their management. Twenty-five papers were presented covering work from various universities, government agencies, and practicing engineering groups.

Results

The inventory data for Four Mile Creek watershed, presented in Table 1, show that land planted to row-crops (corn and soybeans) accounted for 80% of the watershed area for 1979 and 1980, an increase of about 3% from the 1976 to 1978 study period, and an increase of 25% from 1970. The percentage of corn fertilized increased from 88% in 1970 to 99% in 1980, for soybeans the proportions were 4 and 28%, respectively. Application of N on the whole watershed increased a factor of 2.3 times in those ten years, as a result of increased percentage of corn fertilized, increased area planted to corn (39 to 56%), and increased application rate (123 to 178 kg/ha). Although application rates of P on corn and soybeans (and K on soybeans) decreased, the area fertilized increased substantially, so application of P to the whole watershed increased 1.5 times (1.8 times for K).

Herbicide use on corn and soybeans increased from 1970 (70 and 75%, respectively) to the point in 1980 when over 99% of the row-crop area received herbicide treatment. Five herbicides, alachlor, atrazine, butylate, cyanazine and 2,4-D, represented at least 90% by weight of herbicides used on corn. For soybeans, the five herbicides, alachlor, bentazon, chloramben, metribuzin and trifluralin, represented at least 90% by weight of herbicides used. Insecticide use increased from 54% of the corn area treated in 1970 to 70% in 1980; soybeans received no insecticide. Five insecticides, carbofuran, chlorpyrifos, fonofos, phorate and terbufos, represented over 95% by weight of the insecticide used.

Table 1. *Four Mile Creek Watershed Inventory*

	*1970**	*1979*	*1980*
Corn (% area)	*39*	*50*	*56*
fertilized (%)	*88*	*98*	*99*
N (kg/ha)	*123*	*181*	*178*
P_2O_5 (kg/ha)	*71*	*61*	*62*
herbicide (%)	*71*	*98*	*99*
insecticide (%)	*54*	*78*	*70*
Soybeans (% area)	*16*	*30*	*24*
fertilized (%)	*4*	*26*	*28*
P_2O_5 (kg/ha)	*76*	*52*	*57*
herbicide (%)	*75*	*99*	*100*

**Values have been revised since Part I report*

With respect to tillage, the biggest change from 1976 to 1980 came with substitution of use of a disk or chisel for use of the moldboard plow for primary tillage. In 1976, 51, 38 and 11% of the cropland (corn, soybeans, oats, hay and pasture) were moldboard plowed, disked and chisel plowed, respectively. In 1980, the corresponding figures were 16, 54 and 28% (there was 1% buffalo-till and less than 1% no-till). In 1976, 0.5% of the cropland was terraced; in 1980, 3% was terraced. Contouring increased from 6% of the row-cropped land in 1976 to 19% in 1980.

As shown in Table 2, precipitation in the watershed during the study period varied significantly from the average yearly precipitation of about 823 mm for the area. In 1979, precipitation in the watershed was 186 mm above the average and, in 1980, 79 mm below average. Not only was the rainfall amount in 1979 above average, rainfall intensities at individual rain gages within the watershed registered four particularly severe events in June and July (13 events total) with return intervals from 5 to 100 years for different durations. This rainfall, coupled with a soil profile well filled with moisture in the fall of 1978, resulted in large amounts of runoff. About 45% of the total stream flow in the 5-year study (1976 to 1980) occurred in 1979. Although rainfall was below average in 1980, there were

Table 2. *Nutrients and Sediment in Precipitation, Surface Runoff, Tile, and Creek Flow*

		Amount	NH_4-N		NO_3-N		PO_4-P		Cl		TDS		Sediment	
	Year	mm	ppm	kg/ha	ppm	kg/ha	ppm	kg/ha	ppm	kg/ha	ppm	kg/ha	ppm	kg/ha
Precipitation	1979	1009	0.59	5.97	0.6	6.3	0.035	0.357	1.6	16.2	7	74	-	-
	1980	744	0.70	5.24	0.8	5.7	0.063	0.467	0.8	6.1	11	82	-	-
Runoff														
Corn:														
Site 1	1979	251.5	0.34	0.86	2.2	5.7	0.096	0.242	4.0	10.1	69	175	20424	51369
Site 2*	1980	119.6	0.52	0.62	1.3	1.6	0.723	0.865	10.2	12.2	88	105	9245	11061
Soybeans:														
Site 2	1979	199.3	0.14	0.28	1.0	2.0	0.120	0.240	3.6	7.2	91	180	37771	75272
Site 1*	1980	88.4	0.52	0.46	1.3	1.1	1.512	1.336	20.4	18.1	133	118	2458	2172
Pasture:														
Site 3	1979	66.1	0.31	0.21	1.0	.6	0.787	0.520	3.7	2.4	83	55	64	42
	1980	45.3	0.47	0.21	1.1	.5	0.930	0.421	8.2	3.7	63	29	30	14
Tile drainage	1979	-	0.12	-	12.3	-	0.090	-	16.1	-	316	-	-	-
	1980	-	0.08	-	11.1	-	0.082	-	19.0	-	331	-	-	-
Intra basin														
Site 7	1979	111.4	0.52	0.57	3.5	3.9	0.671	0.748	8.8	9.8	135	150	1100	1225
284 ha	1980	92.4	1.02	0.94	3.4	3.1	0.808	0.746	7.6	7.0	148	137	6034	5576
Site 8	1979	137.4	0.22	0.30	2.1	2.8	0.293	0.403	4.8	6.7	96	132	13769	18914
149 ha	1980	74.0	0.36	0.26	1.5	1.1	0.328	0.243	7.4	5.5	97	72	8828	6534
Creek														
Site 6	1979	394.3	0.20	0.72	8.8	30.7	0.115	0.402	11.2	39.1	230	804	4328	15120
345 ha	1980	143.1	0.63	0.90	6.1	8.8	0.318	0.456	13.5	19.3	214	306	2046	2954
Site 5	1979	422.7	0.54	2.29	8.9	37.7	0.248	1.048	14.2	59.9	267	1129	1693	7156
3575 ha	1980	179.2	0.70	1.25	7.1	12.7	0.209	0.375	14.0	25.0	221	396	2075	3718
Site 4	1979	444.6	0.52	2.33	8.0	35.4	0.155	0.689	12.0	53.3	220	977	1712	7612
5055 ha	1980	182.4	0.51	0.93	6.3	11.5	0.141	0.258	13.2	24.1	247	450	2062	3760

**Sites 1 and 2 were fall fertilized before the 1980 growing season; fertilizer was incorporated in the spring by chisel plowing on site 1 and disking on site 2*

eight runoff events in that year. In late 1979, the soil profile was wetter than in the fall of 1978. This, coupled with the significant rainfall events that occurred during the 1980 growing season, resulted in runoff from the watershed.

For all but the four extreme events of 1979, the field that had been in corn the previous year and had been spring-plowed had the least runoff (or in some cases no runoff when there was runoff from the other row-cropped site). In addition, the plowed field (in soybeans) was cultivated once in June and once in July each year, but the corn field was not cultivated. For the four extreme events in June and July 1979, runoff volumes from sites 1 and 2 were nearly identical, seemingly independent of previous or recent tillage, crop or crop canopy, or watershed topography. For these events, runoff ranged from 20 to 59% of precipitation.

The portion of stream flow during storm events that was subsurface flow was determined by an interpolation technique between the time of beginning of runoff and the time runoff was calculated to have ended. Because there was such a large difference between NO_3-N, Cl and TDS concentrations in stream flow which was all subsurface drainage (very similar to concentrations in the tile drainage water) and in surface runoff, knowledge of the concentrations in the total stream flow at any given time could be used to estimate the portion of stream flow attributable to subsurface drainage and (or) surface runoff at that time.

The four severe events in 1979 caused severe erosion and sediment transport. As also evidenced in 1976 to 1978, 1979 flow-weighted sediment concentrations for the larger events were generally greater for the soybean cropped field (moldboard plowed before planting) than for the corn field (disked before planting). In 1980, when the soybean cropped field was chisel plowed, 33% residue cover remained after planting, and sediment concentrations were less than those for the corn field, which had been disked and had only 8% residue cover after planting. Much less rainfall-runoff occurred from the chisel plowed field, resulting in soil losses only one-fifth of those from the disked field. For all events analyzed, the sediment load decreased as sediment moved from field (sites 1 and 2) to intra-basin (sites 7 and 8) to stream (site 4).

Annual nutrient loss data and nutrient amounts deposited with precipitation for 1979 and 1980 are presented in Table 2 together with annual flow-weighted concentrations and arithmetic average concentrations of nutrients in tile drainage water. During snowmelt, NH_4-N concentrations in runoff from the row-cropped fields were somewhat higher than concentrations later in the growing season. One of the differences between snowmelt runoff and later rainfall runoff is the degree of contact with the soil. NH_4-N concentrations in runoff from the corn field in 1979 and 1980 were highest in runoff for the first events following N fertilizer application, although the fertilizer had been incorporated by disking. Annual NH_4-N losses from the single cover fields and pasture were all less than 1 kg/ha, and much less than the 5 to 6 kg/ha deposited with precipitation. Total watershed losses were at most 2.3 kg/ha, the majority of which occurred during snowmelt in 1979.

During snowmelt, NO_3-N concentrations in runoff from the three single cover fields and pasture were very similar to concentrations in the snowfall itself. As evidenced by the high NO_3-N concentrations in tile drainage water, the leachability of NO_3-N can result in large losses. The very close match between NO_3-N concentrations in subsurface stream flow and in the tile drainage water, would indicate that during the sustained high flow between closely spaced rainfall-runoff events, most of the stream flow consisted of subsurface drainage from tile drains. Annual NO_3-N losses in surface runoff averaged 2.6 kg/ha from the row-cropped fields and less than 1 kg/ha from the pasture. This was less than the 6 kg/ha deposited with precipitation. Annual NO_3-N losses with stream flow were much larger because they included leaching losses.

During snowmelt in 1979, PO_4-P concentrations in runoff from the row-cropped fields were similar (<0.1 ppm) to those for rainfall-runoff events later in the growing season after tillage and planting. This indicates that the unincorporated corn and soybean residue was releasing little, if any, PO_4-P to snowmelt runoff. PO_4-P levels in snowmelt runoff from the pasture were high (nearly 1 ppm), however, because of dead and decaying grass, animal wastes, and previously applied P fertilizer on the soil surface. The high in-stream levels of PO_4-P during snowmelt probably also resulted from these surface sources of PO_4-P The higher concentrations in field runoff in 1980 resulted from P application in December 1979 without soil incorporation. Losses were only about 1 kg/ha, however, with winter rains and snowmelt in 1980.

In general, nutrient concentrations in sediment increased as sediment concentrations in runoff decreased. This would be expected if chemical activity of sediment increased as sediment size decreased (greater surface area per unit mass) and sediment size decreased as sediment concentrations decreased. The equation:

$$\text{nutrient concentration} = a\,(\text{sediment concentration})^{-b}$$

where a and b are empirical parameters, fitted the nutrient and sediment concentration data quite well. For the row-cropped fields, total N and P losses were dominated by the losses associated with sediment.

Table 3 shows the percentages of applied herbicides lost from the row-crop fields and the whole watershed on an annual basis for 1979 and 1980. For 1979, there were three particularly severe events for which runoff from the row-cropped fields exceeded 34 mm, and a fourth for which runoff exceeded 12 mm. As is almost always the case, the first significant storm after herbicide application resulted in the largest single-event field losses. From 63 to 93% of the measured annual losses from sites 1 and 2 occurred during this one storm. For the whole watershed, from 46 to 74% of the annual losses occurred during this event. Because of the severe events in 1979, field runoff losses were much higher than they were in 1976 to 1978, when losses of the four herbicides studied never exceeded 1% of the amounts applied. The greatest recorded loss in 1979 was for metribuzin, when 7.2% of that applied was lost from the field and 2.0% from the whole watershed. The trend of lower storm losses from the watershed as a whole than those measured at the field borders, which was evident in the 1976 to 1978 data, was also evident in 1979.

Table 3. *Percentage of Applied Herbicides Lost*

Year	Site	Alachlor	Metribuzin	Propachlor	Cyanazine
1979	field	2.7	7.2	0.6	5.6
	4 mi watershed	1.1	2.0	0.6	1.7
1980	field	0.6	1.1	0.7	2.8
	4 mi watershed	1.9	0.8	0.4	1.6

In 1980, storms in a 5-day period in late spring resulted in most of the measured herbicide runoff losses from both the field and whole watershed. These events also accounted for most of the rainfall-runoff that occurred in 1980.

The May-June surface runoff amounts for the whole watershed for 1979 and 1980 were both about 42 mm, and annual herbicide losses were similar (although the relative amounts of alachlor and metribuzin lost were reversed). The May-June surface runoff amounts for the disked corn field (site 1 in 1979, site 2 in 1980) were also similar (51 mm in 1979, 48 mm in 1980), with cyanazine losses somewhat less for 1980, and propachlor losses somewhat greater. For the soybean field, which was moldboard plowed (site 2) in 1979, but chisel plowed (site 1) in 1980, May-June runoff was much less in 1980 (14 mm) than in 1979 (48 mm), and therefore alachlor and metribuzin field losses were also less in 1980. The herbicides were so much affected by decreased runoff that the trend of larger field losses than whole watershed losses was reversed for alachlor and was marginal for metribuzin. It appears that for 1980, chisel plowing of site 1 decreased herbicide losses by decreasing runoff as well as by decreasing erosion). For all cases a majority of the annual losses occurred with water.

Observations and Conclusions

- For smaller, less severe runoff events, the fields with the most recent or more intensive tillage had significantly less runoff.
- For the severe runoff events of 1979 (runoff total 120 mm), runoff amounts from both row crop fields for each event were nearly identical, despite differences in timing and degree of tillage and in crop canopy.
- Surface runoff from the pasture was mostly snowmelt; runoff from rainfall occurred only during intense rain storms.
- Flow from the whole watershed was roughly half subsurface flow and half surface runoff. Half or more of the surface runoff was snowmelt runoff.
- During extended high flows between surface runoff events, high instream NO_3-N concentrations were very similar to those in monitored shallow subsurface tile drains, implying that much of the stream flow at these times was from the drains. During low flow winter conditions, in-stream NO_3-N concentrations were much lower.
- For the study conditions of this watershed, the difference between concentrations of NO_3-N, Cl and TDS in subsurface flow (measured in tile drainage water) and concentrations in field surface runoff indicates that these data could be used to predict the percentage of surface runoff in stream flow.
- Generally, sediment concentrations in runoff from the soybean field (corn residue incorporated by moldboard plowing) were appreciably greater than for the corn field (disked soybean residue); however, the opposite was true when a chisel plow was used to incorporate the corn residue.
- For all rainfall-runoff events analyzed, as runoff flowed from field to intra-basin station to the main channel, the sediment load decreased on a unit-area basis. For snowmelt, however, field losses were less than stream losses on the unit-area basis.
- In the long term, the stream channel is becoming deeper and wider, thereby providing a source of sediment.
- For rainfall-runoff from row-cropped fields not recently fertilized, NH_4-N concentrations in runoff were less than in precipitation because of extraction by adsorption to the soil.
- Because of the large volumes and the high NO_3-N concentrations of subsurface drainage, NO_3-N losses from the watershed in stream flow

(1979 and 1980) averaged 25 kg/ha, 28% of the applied N.

- Concentrations of PO_4-P in winter surface runoff and snowmelt following fall P application to the row-cropped fields without incorporation, were higher by a factor of 10 to 15 times than when P had not been applied, although losses were only about 1 kg/ha.
- Total N and P concentrations in sediment in runoff samples increased as the sediment concentration decreased. The equation: nutrient concentration = a (sediment concentration)$^{-b}$, where a and b are empirical parameters, fitted the data quite well.
- The severe runoff-erosion events in 1979 resulted in herbicide field runoff losses as high as 7.2%, most of which was with water for all four herbicides studied; maximum loss in 1980 was 2.8%. Losses from the whole watershed were less: a maximum of 2.0% in 1979 and 1.9% in 1980.
- Chisel plowing, by reducing runoff and erosion, in 1980 reduced herbicide field runoff losses of alachlor to below those for the whole watershed (on a percent of applied basis); whereas in the previous four years of moldboard plowing, field alachlor losses were greater.
- Concern for (and modeling of) pollutants transported with subsurface drainage needs to be emphasized, along with that for surface runoff, in cases where volume of subsurface drainage is significant.
- The factors important in determining the effect of recent tillage, including cultivation, on runoff volumes, and how this effect declines with time (or precipitation), need to be defined.
- Factors determining sediment deposition within an agricultural watershed, which is important in determining the sediment delivery, need to be quantified.
- The possibility that a cycle exists whereby sediment is deposited in water courses during lesser events to be eroded during high flows, such as snowmelt, needs further study.
- Additional analyses of chemical-sediment partitioning and enrichment relative to sediment particle size should be performed.
- Better management systems for the increasing amounts of nitrogen applied to crops need to be developed and implemented to decrease the environmental, as well as economic and energy concerns associated with NO_3-N leaching losses.
- The problems of chemical application with conservation tillage (e.g., incorporation of nutrients without incorporation of residue, or possible runoff and volatilization losses of herbicides applied to crop residues) need to be solved to obtain the greatest benefits from this increasingly accepted practice.

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The complete report, entitled "Field-to-Stream Transport of Agricultural Chemicals and Sediment in an Iowa Watershed: Part II. Data Base for Model Testing (1979-1980)," (Order No. PB 84-177 419; Cost: $34.00, subject to change) will be available only from:

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