Conservation Tillage

Effects on Water Quality

Conservation tillage practices have a major impact on water quality in addition to reducing soil erosion. Sediment and chemicals (pesticides and plant nutrients) are the two main types of contaminants affected by conservation tillage.

Sediment is the largest pollutant by volume of suface water in Iowa. Most sediment comes from agricultural sources. Sediment increases the turbidity of water, thereby reducing light penetration, impairing photosynthesis, altering oxygen relationships, and reducing the available food supply for certain aquatic organisms. It can destroy fish populations in areas where sediment deposits cover spawning beds. Increased sediment also fills lakes and reservoirs.

The reduced soil erosion from conservation tillage systems, compared with moldboard plowing or conventional tillage systems, beneficially decreases the problems associated with sediment in water.

Conservation tillage practices also affect the chemical losses in surface runoff water and sediment. Surface drainage water and sediment carry dissolved nutrients and pesticides.

The largest quantities of total P and usually of total N lost from Iowa fields are associated with sediment in runoff water (see table 1). If chemical concentrations in sediment were constant, decreasing soil losses by one-half with conservation tillage practices would decrease chemical losses from sediment by one-half. However, the finer, more chemically active clay particles are more easily eroded than larger, less chemically active soil particles. Therefore, a reduction in soil erosion will reduce the losses of chemicals attached to sediment, but not quite proportionally.

Conservation tillage usually reduces the amount of runoff, but the amount of reduction is highly variable. Less runoff generally means less chemical loss, but this depends on the timing and duration of rainfall.

Conservation tillage practices sometimes have been falsely criticized for increasing chemical contamination of groundwater for two main reasons: increased herbicide use and increased leaching.

One theory is that more herbicide is required for weed control in conservation tillage compared with conventional tillage systems. But in Iowa, recommended herbicide rates are the same for all tillage systems. Sometimes a burndown herbicide is used in conservation tillage to control vegetation instead of mechanical tillage, but such herbicides usually are strongly adsorbed by the soil and therefore resist leaching.

Some no-till farmers have eliminated the need for a burndown herbicide by applying split applications of herbicides. The first application is put on before most weeds start to germinate and the second application is either a preemergence or a postemergence herbicide. This practice still requires spraying the field twice, but generally the total amount of herbicide used is the same as for one application.

Another criticism is that increased groundwater contamination will result from increased leaching through macropores, particularly for no-till. Macropores are small, open channels in soil that are created by earthworm activity, soil cracking, and root growth. Macropores are more prevalent in no-till fields because tillage mechanically mixes the upper soil profile, thus disturbing macropores. These macropores can allow larger quantities of water to infiltrate faster in the soil. This increased infiltration creates concern over increased leaching chemicals.

However, studies have shown that macropores can be beneficial if they allow water to bypass chemicals adsorbed within the top few inches of soil. This is highly dependent on how strongly the chemical adsorbs to the soil and the timing and duration of rainfall after chemical application. Macropores may allow highly soluble chemicals to infiltrate deeper and faster in the soil if a heavy rain occurs shortly after application.

IOWA STATE UNIVERSITY
EXTENSION
Ames, Iowa 50011

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One experiment near Ames compared the movement of NO_3-N through no-till and moldboard plowed field plots after two simulated rainfalls. The first simulated rainfall was a 5-inch rain followed the next day by a 7.5-inch rain. Soil samples were taken after each rainfall to measure the NO_3-N remaining in the soil at various depths. Table 2 shows that more NO_3-N remained in the no-till field plots than in the moldboard plowed field plots. This test helps show that macropores do not always cause increased NO_3-N leaching.

There is increasing concern over traces of herbicides detected in water samples taken from wells and drainage tiles. Preserving the quality of groundwater is vital, but one must consider the magnitude of the herbicide concentrations detected in groundwater and subsurface runoff compared to those measured in surface runoff.

Surface water is a source of drinking water for some Iowans, so it is important to protect it. Herbicide concentrations in sediment from a treated field often exceed 1 part per million (ppm), particularly for the first rainfall after application. Herbicide concentrations in surface runoff water also can exceed 1 ppm for herbicides that are not strongly adsorbed if rainfall occurs shortly after application.

By comparison, herbicide concentrations found in groundwater or in water collected from drainage tile flow usually are much lower than for surface runoff. These concentrations generally range from below the detection limit to 1 part per billion (ppb). Higher concentrations have been detected, but usually point sources of contamination were suspected in these situations. This means that, with normal agricultural practices, herbicide concentrations in surface runoff shortly after application are about 1,000 times greater than those detected in groundwater.

In conclusion, reducing the amount of tillage on Iowa's valuable soils will help maintain the quality of the state's land and water resources.

Table 1. N and P associated with runoff and sediment from three sites in east central Iowa.

Year and site	Flow in.	Sediment ton/A	N(lb./A) Soluble	N(lb./A) Sediment	P(lb./A) Soluble	P(lb./A) sediment
1979						
Corn field	9.9	22.9	5.9	94.4	0.21	29.2
Soybean field	7.8	33.6	2.1	132.8	0.21	40.0
Stream	17.5*	3.4	33.6	20.7	0.86	6.9
1980						
Corn field	4.7	1.0	2.0	22.4	0.77	7.4
Soybean field	3.5	1.0	1.4	4.7	1.20	1.6
Stream	7.2	1.1	11.1	10.2	0.23	3.4

*Stream flow includes surface runoff and subsurface drainage.

From H. P. Johnson and J. L. Baker. 1980. *Field-to-stream transport of agricultural chemicals and sediment in an Iowa watershed. Part 2: Data base for modeling (1979-80).* Completion report.

Table 2. Average nitrate-nitrogen content in the soil profile after 5.0 and 7.5 in. of rainfall for no-till and moldboard plow plots.

Soil depth, in.	Before rainfall	No-till, N-surface rainfall, in.		Plow, N-surface rainfall, in.		Plow, N-incorporated rainfall, in.	
		5.0	**7.5**	**5.0**	**7.5**	**5.0**	**7.5**
	Nitrate-Nitrogen content, lb./acre						
0-6	204.8*	86.8	64.7	17.8	5.7	8.2	4.2
6-12	65.5	74.1	66.8	61.2	29.9	43.5	26.4
12-18	47.6	56.5	53.4	63.5	47.3	60.8	31.8
18-24	27.0	44.7	46.8	48.1	44.4	67.7	36.8
24-36	22.6	50.3	64.2	56.6	69.1	104.7	73.2
36-48	17.4	37.8	50.8	31.2	52.4	40.0	63.0
48-60	18.1	25.2	35.3	27.0	34.4	28.8	37.0
Total NO_3-N in the 0 to 60 in. depth	403.1	375.5	382.1	305.4	283.3	353.8	272.4
Net NO_3-N leaching loss below the 60 in. depth		25.8**	19.2**	108.4	130.5	39.4	120.9

*Includes an average 134.7 lb./A of applied NO_3-N (actually 132.9 + 7 and 145.4 + 10 lb./A of NO_3-N was surface applied on no-till and moldboard plots respectively, and 124.9 + 4 lb./A of NO_3-N was surface incorporated on moldboard plots).
**That the data show an apparent small decrease in NO_3-N leaching with increased rain may be due to sampling and/or analytical errors (NO_3-N analyses are accurate to about + 5 percent).

From Kanwar, R. S., J. L. Baker, and J. M. Laflen. 1985. "Nitrate movement through the soil profile in relation to tillage system and fertilizer application method." *Transactions of the ASAE,* 28:1802-1807.

For more information on conservation tillage systems, see the following publications:

AE-3049 *Conservation Tillage—Planning*
AE-3050 *Conservation Tillage—Effects on Soil Erosion*
AE-3051 *Conservation Tillage—Effects on Water Quality*
AE-3052 *Conservation Tillage—No-till Systems*
AE-3053 *Conservation Tillage—Ridge-till Systems*
AE-3054 *Conservation Tillage—Fertility Practices and Equipment for No-till and Ridge-till*
AE-3055 *Conservation Tillage—Cultivators for No-till and Ridge-till*
AE-3056 *Conservation Tillage—Planters for No-till*
AE-3057 *Conservation Tillage—Planters for Ridge-till*

Prepared by Vincent J. McFadden, extension soil and water engineering specialist, Northeast Area.

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