ACES News
University of Illinois College of Agricultural, Consumer and Environmental Sciences

August 14, 2003

Shallow Drain Tiles Have Deep Impact on Nitrates in Water

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October 2, 2002

URBANA - Subsurface drain tiles have long been known to move more than just water. They can also become express routes for nitrates moving from farm fields into streams and rivers.

The good news is that University of Illinois research has discovered that producers can significantly reduce the amount of nitrate moving through drainage systems if the drain tiles are placed shallow.

Elevated nitrate levels in drinking water have been associated with blue-baby syndrome, which affects the transport of oxygen in infants. High nitrates have also been linked to bladder cancer and non-Hodgkin's lymphoma, as well as environmental problems such as hypoxia in the Gulf of Mexico.

These are all reasons why Richard Cooke, University of Illinois agricultural engineer, is looking at different ways to substantially reduce the amount of nitrates that find their way into our water sources – without adversely affecting crop yields.

“One method is to adjust the design, specifically the depth and spacing of the drain tiles, to see how that affects the nitrates transported to the tiles,” he said.

To that end, Cooke installed a number of tile drainage systems at sites around East Central Illinois. At one site south of Longview, Cooke placed tiles in the same field at three different depths - 2, 3 and 4 feet. Then he measured the water flow and the nitrates coming from these tiles.

“There seems to be a direct correlation between depth and nitrate loads,” said Cooke. “The deeper the tile, the more nitrate load you have coming out of the tile. There’s more coming out of the 4-foot tile than the 3-foot and more out of the 3-foot tile than the 2-foot.”

Cooke said this is because there is more water leaving the 4-foot tile than the 3- or 2-foot tile. “I didn’t notice any difference in nitrate concentration, but there is a difference in flow rate. This difference in flow rate translates into a difference in nitrate loads.”

Because of these results, Cooke suggests that farmers install tile at the shallow end of the range of depth recommended in the Illinois Drainage Guide: 3 feet deep in Drummer, for example.

“Draining the water table down to 3 feet will facilitate planting just as readily as draining it down to 4 feet,” he said. “The shallow, more closely spaced tiles drain just as fast as, if not faster, than the deeper tiles.”

He pointed out that by the time crop roots reach the 3-foot depth, the water table will have dropped even further because of evaporation and the consumption of water stored in the soil--in all but the wettest years.

"In dry years, such as this one," he added, "the shallow tiles will actually be of some benefit. Thirty-year computer simulations that we have done do not show any significant change in yield by going to a shallower system."

Cooke said there is also a move by farmers to install tiles closer than what is recommended in the drainage guide. However, this design change has not been motivated by water-quality concerns. Farmers have observed that yield drops off with distance from the tile.

Putting the tiles closer together does increase the cost of drainage, Cooke added. A system spaced at 60 feet costs about a third more than one spaced at 80 feet. However, the closer spaced tiles could be smaller, so some of the added cost could be recovered in that way.

In addition to design changes, a second method under study for reducing nitrate loads is edge-of-field treatment. Cooke passes the water through a subsurface bio-reactor after the water has left the field, but before the tile line discharges water into a stream or river.

The subsurface bio-reactor is simply a trench, 1-1/2 to 2 feet wide and 1-1/2 to 2 feet below the level of the tile. The trench can be anywhere from 60 to 200 feet long. It is filled with some kind of carbon material, usually wood chips or corn cobs, combined with 1-inch gravel for structural support. An inlet pipe from the tile extends 20 feet into the carbon medium.

Bacteria that live in the soil use the carbon as an energy source and also feed on nitrates. They break down the nitrate into nitrogen gas and other oxides of nitrogen, which greatly decreases the nitrate concentration.

Cooke has installed bio-reactors at locations near Roberts, Chatsworth, DeKalb, Cerro Gordo, and Pekin, Iowa, and one will be installed near Rossville soon.

“In one that is 60 feet long, there’s a 75-percent reduction of nitrate concentration,” he said. “In the ones that are 200 feet long, I’m getting 100-percent reduction, so there is really no measurable nitrate coming out of those tiles. However, some of the tile flow is bypassing the bio-reactor. The challenge now is to increase the flow rate through the reactors without decreasing their effectiveness. ”

Such dramatic results are compelling, and Cooke will continue to monitor the experimental drainage systems over three cropping seasons. If these preliminary results hold true, the combined use of closely spaced, shallow drain tiles and subsurface bio-reactors could be the answer that will keep everyone – farmers, health activists and environmentalists – happy.

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