Concentrating on nutrient loss:

A review of tile drainage nutrient concentrations

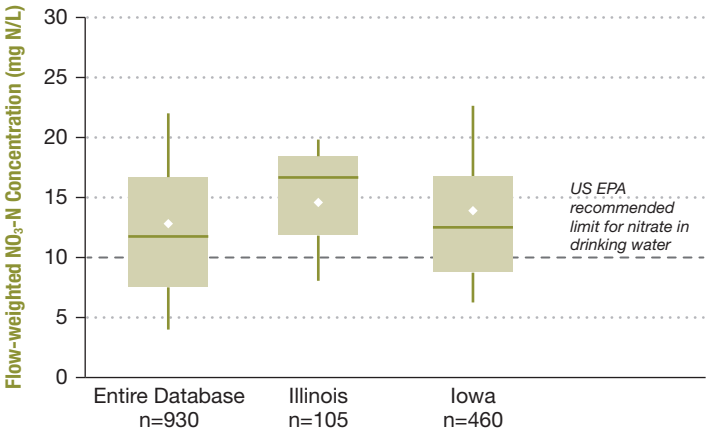
Tile drainage is required across much of the United States Midwest region for highly productive cropping systems. However, this critical infrastructure is also known to be a source of nutrient loss from fields. The purpose of this factsheet is to present some of the most common reasons why nutrient concentrations differ in tile drainage water from different fields.

A review of more than 70 North American drainage studies showed the average tile drainage nitrate-nitrogen (NO_3-N) concentration was 12.88 mg NO_3-N/L (FIGURE 1), which was above the United States Environmental Protection Agency's recommended limit for drinking water of 10 mg NO_3-N/L. Illinois and Iowa, the states with the most tile-drained ground, averaged 14.09 and 13.22 mg NO_3-N/L, respectively.

There have been relatively fewer tile drainage dissolved phosphorus studies than nitrate studies (FIGURE 2). However, dissolved phosphorus can be a concern in tile drainage water depending on the location and site conditions. Very small phosphorus losses from fields are often deemed inconsequential agronomically, but such low concentrations are known to cause serious environmental impacts.

SUMMARY

- Crop selection and nitrogen application rates applied to corn were strong predictors of nitrate concentrations in tile drainage.
- The distinction between tile drainage nitrate concentrations and nitrate loads cannot be overemphasized. While tile nitrate concentrations are relatively easy to assess from time to time by collecting a water sample, the true evaluation of nitrogen loss from a field also considers the volume of drainage water. The calculation of nitrogen load leaving a field considers both nitrate concentrations in water samples collected over time and the total volume of drainage water that has left the field.
- Tile drainage nitrate concentrations will vary from field to field and from an individual tile outlet over time. Specific cropping management decisions based on one individual tile sample should be interpreted with caution.



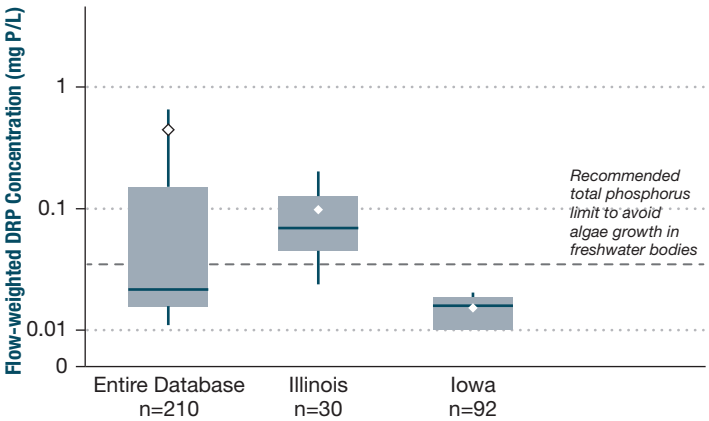


FIGURE 1. Annual flow-weighted nitrate-nitrogen concentrations across a recently compiled database of North American drainage studies. The dashed line signifies the United States Environmental Protection Agency's recommended limit for nitrate in drinking water of 10 mg NO_3-N/L.

Graph Legend

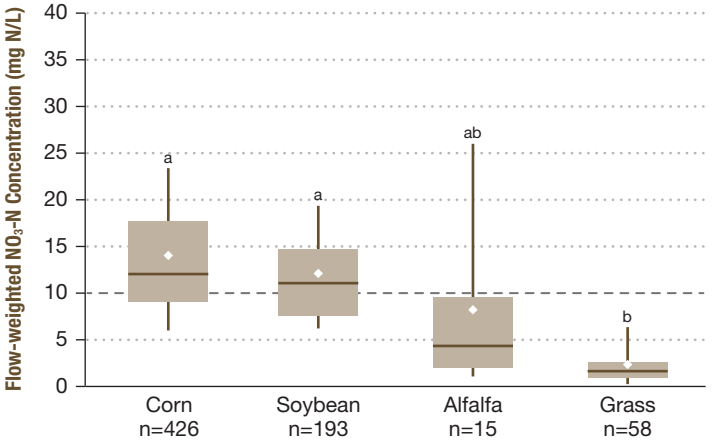
The boxes encompass the 25th and 75th percentiles, and the stems encompass the 10th and 90th percentiles. The solid horizontal line is the median concentration, and the diamond is the mean or average concentration. "n = …" is the number of site-years compiled in the database for each category.

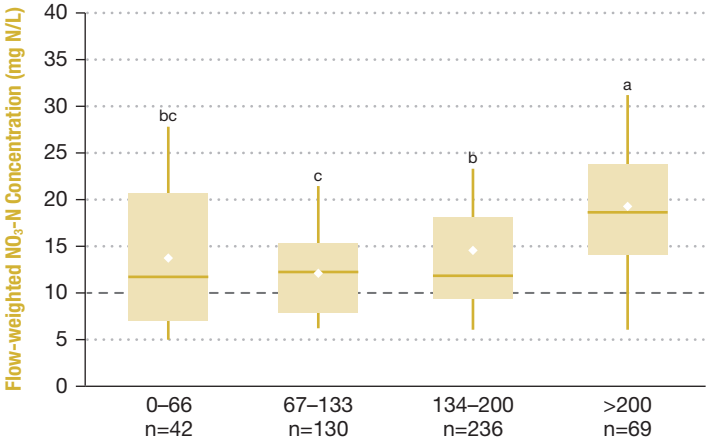
FIGURE 2. Annual flow-weighted dissolved reactive phosphorus (DRP) concentrations across a recently compiled database of North American drainage studies. A recommended phosphorus threshold to avoid algae growth in freshwater bodies like lakes and reservoirs in the Corn Belt and Northern Great Plains is 0.0375 mg total phosphorus/L (dashed line). The dissolved reactive phosphorus concentrations on the graph only comprise a portion of total phosphorus concentrations indicated with the dashed line, thus underestimating the potential proximity to this recommended limit. Note the y-axis is in log scale.

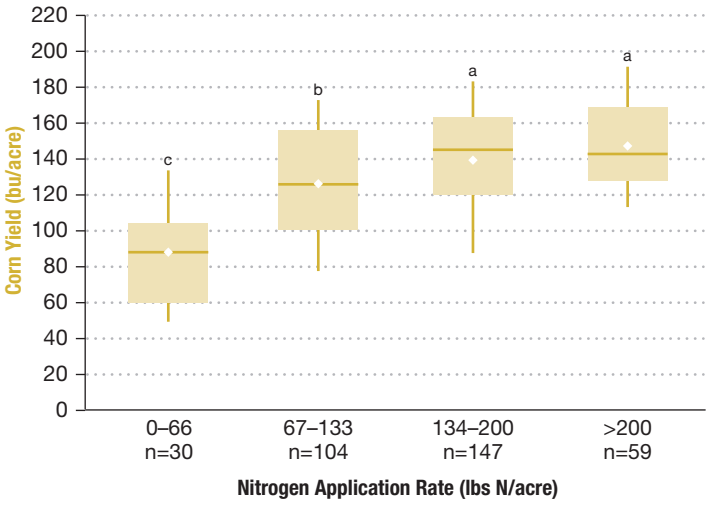
A common question about nitrate loss in tiles is if there is a "baseline" amount of nitrogen lost from soils. Drainage nitrate concentrations from perennial crops, which is the cropping system most closely resembling native prairie, give the best estimate. Perennial grasses and perennial legumes like alfalfa have much lower average tile drainage nitrate concentrations than annual crops like corn or soybeans (FIGURE 3). Perennials also uptake water for a longer period of the year than annual crops, thus also reducing the volume of drainage flow. In this way, the practices of incorporating perennials into an extended rotation or growing a perennial bioenergy crop provide a dual benefit for reducing nitrate losses from drained lands.

FIGURE 3. Annual flow-weighted nitrate-nitrogen concentrations by crop type. Means with the same letter are not significantly different from each other (α=0.05). The corn, soybean, alfalfa, and grass mean values (diamonds) are 13.98, 12.09, 8.23, and 2.26 mg NO_3-N/L, respectively.

FIGURE 4. Annual flow-weighted nitrate-nitrogen concentrations (top) and corn yield (bottom) by grouped nitrogen application rate for corn site-years in North American drainage studies. Means with the same letter are not significantly different from each other (α=0.05).







Nitrogen application rate was the strongest predictor of tile drainage nitrate concentrations when corn was grown. When nitrogen application rates were grouped into four categories, the three highest application rate categories exhibited significantly increasing tile drainage nitrate concentrations (FIGURE 4 TOP). However, only the highest nitrogen application rate category had nitrate concentrations statistically greater than the lowest rate category. These results emphasize that a nitrogen application rate much lower than the crop demand (that is, a rate on the order of 0-66 lb N/ac) does not necessarily equate with improved water quality. Nitrogen application rate is also known to be a strong driver of corn yield, with yields plateauing at high nitrogen application rates (FIGURE 4 BOTTOM).

For more information, contact: Dr. Laura Christianson, Department of Crop Sciences, University of Illinois (LEChris@illinois.edu). The tile drainage nutrient concentrations presented here were compiled from a review of more than 70 peer-reviewed scientific journal articles. More information about this project and the resulting database is available at **ars.usda.gov/plains-area/temple-tx/grassland-soil-and-water-research-laboratory/docs/manage-nutrient-loss-database/**.

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