Questions and Answers Regarding Nitrogen and Water Quality

Due to increased awareness of nutrient management and water quality, Iowa State University Extension and Outreach has received a number of questions about nitrogen movement from Iowa's cropping systems into surface and subsurface water. The following frequently asked questions and answers have been prepared to clarify aspects of nitrogen management and nitrogen movement in the soil system.

Nitrogen Fertilizer

Q: Is there a legal limit to the amount of fertilizer that can be applied?

A: For commercial fertilizer, the answer is no. However, from an economic standpoint, farmers choose to balance nutrient applications with a crop yield response. If a farmer over-applies nutrients, then nutrients are wasted and extra dollars are spent, if a farmer under-applies nutrients then a reduction in yield causes loss of revenue. If the farm operation has livestock or is distributing manure to other acres, and is of a certain size, they are required to apply manure at the rate determined by their state required manure management plan.

Q. How do farmers determine how much fertilizer they should apply?

A: Nutrients are required to grow Iowa's major crops, corn and soybeans. Farmers and agronomists use soil testing as a means to determine the nutrient-supplying capacity of the soil for certain nutrients and if additional nutrient inputs such as commercial fertilizer or manure applications are needed. Under-application of nutrients can lead to loss of revenue from loss of crop yield and over-application can also lead to loss of revenue when supplying nutrients beyond what is needed to maximize crop production. Over-application can also lead to increased risk of loss of nutrients to the environment.

Determining nitrogen (N) application rates is based on grain yield response to nitrogen rate trials (varying rates of nitrogen inputs compared to yield response). The goal of conducting nitrogen rate trials is to find the point where the value from grain yield increase by adding more nitrogen matches the cost of the added nitrogen. This concept, known as the maximum return to nitrogen (MRTN) is the foundation of web-based tool used in Iowa, the Corn Nitrogen Rate Calculator (http://extension.agron.iastate.edu/soilfertility/nrate.aspx).
Please refer to ISU publication PM 2015, *Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn (https://store.extension.iastate.edu/Product/Concepts-and-Rationale-for-Regional-Nitrogen-Rate-Guidelines-for-Corn*), for the science behind nitrogen rate guidelines.

Using soil tests to determine phosphorus (P) and potassium (K) levels in the soil is based on years of soil testing research conducted at Iowa State University. Soil test values are classified into five categories very low (VL), low (L), optimum (Opt), high (H) and very high (VH). The categories represent a decreasing probability of economic yield response to applied nutrients.

Also please refer to ISU publication PM 1688, *A General Guide for Crop Nutrient and Limestone Recommendations in Iowa (*https://store.extension.iastate.edu/Product/A-General-Guide-for-Crop-Nutrient-and-Limestone-Recommendations-in-Iowa), for P, K, zinc (Zn) and limestone recommendations based on soil testing for major agronomic crops grown in Iowa.

Q: How do I know if my corn is getting enough, but not excess N?

A: In-season soil testing including the late spring soil nitrate test (LSNT), measures soil nitrate-N to determine if nitrogen will be adequate or if additional nitrogen is needed. End of season testing, such as the cornstalk nitrate test, can evaluate if more than adequate nitrogen was available to the plant during the growing season.

Q: Are all sources of nitrogen fertilizer equal in terms of impact on water?

A: Nitrogen fertilizer undergoes many processes in the soil, many based on microbial activity and conversion, with rates dependent on moisture and temperature. All sources of commercial nitrogen fertilizer are considered immediately available for crop uptake and can have the same impact on water quality. With manure sources, the nitrogen may take longer to become crop available if the nitrogen is in organic forms. Some manure sources have a high fraction of inorganic nitrogen (as ammonium), and thus behave in a similar way as fertilizer. No matter the source, fertilizer or manure, once nitrogen is converted to the nitrate form, it is subject to the same mechanism of loss, such as leaching.

Q: Does corn production require nitrogen fertilization to produce acceptable yields?

A: If no nitrogen is applied from fertilizer or manure, corn yields with corn following corn would be approximately 60 bu/acre and for corn following soybean would be approximately 115 bu/acre. With adequate nitrogen fertilization, corn yields can easily reach 200 or more bu/acre.

Q: What is the impact of application timing and nitrate levels in surface water?

A: Moving application of nitrogen from a post-harvest fall application to a spring pre-plant application is expected to reduce nitrate-N loss by an average of 6%. A sidedress application of nitrogen after the crop is growing compared to a spring pre-plant

application is expected to reduce nitrate-N loss by an average of 7%.

Nitrate Movement

Q: How do nitrates get into water?

A: Nitrate is a form of nitrogen that is found naturally in soils and becomes available to plants as soil organic matter mineralizes, a natural biologic process that is part of the nitrogen cycle. Nitrate is also found in commercial fertilizer sources or becomes available as a commercial fertilizer source undergoes natural processes in the soil in the presence of the right temperature, moisture and microbial activity. Nitrate can also come from septic systems.

Nitrate is a soluble form of nitrogen that moves with water through the soil. The process of nitrate movement is called leaching. If the landscape is tile-drained, excess water will exit the soil profile via the tiling system more quickly than if the field was not tile drained. This water often carries nitrate. Tile water is often discharged into drainage ditches and drainage ditches drain to surface water sources such as streams and rivers. In non-tiled areas we still see nitrate leaching losses but in these areas the nitrate movement to downstream waters is through natural subsurface flow pathways.

Q: What was nitrate loss before settlement?

A: While difficult to assess without monitoring data, we do have results from replicated plots with diverse prairie where one prairie treatment is fertilized with nitrogen and one is not. We see concentration of nitrate-N of less than 1ppm in drainage from the prairie (with or without fertilization) compared to nitrate-N concentrations of 10-12ppm from a corn/soybean rotation.

Q: What is the expected tile-flow nitrate-N concentration with nitrogen application in a corn production system?

A: If corn is not fertilized with nitrogen, the tile-flow nitrate-N concentration will be approximately 7 ppm from natural processes of microbes mineralizing soil carbon. At optimal nitrogen application rates, that is, at the maximum economic return to nitrogen rate, tile-flow nitrate-N concentration will be approximately 18 ppm for continuous corn and 12 ppm for corn/soybean rotation. The tile-flow nitrate-N concentration increase is 150% for continuous corn and 74% for corn rotated with soybean.

A video was created with Dr. Matt Helmers and Dr. Mike Castellano describing the nitrogen cycle and nitrate loss:
https://www.cals.iastate.edu/nutrientcenter/media/nitrogen-cycle

Nitrogen Loss Reduction Loss

Q: As the landowner, how can I work with my tenant to make sure we are using the best practices for our land and for the water?

A: The Iowa Nutrient Reduction Strategy has identified in-field management practices and edge of field practices and structures that can minimize the loss of nitrogen and phosphorus to water. Have a conversation with your tenant about management practices and structures currently used on your farm. The publication "Reducing Nutrient Loss: Science Shows What Works (https://store.extension.iastate.edu/Product/Reducing-Nutrient-Loss-Science-Shows-What-Works) outlines the average effectiveness of each practice for reducing nitrogen and phosphorus loss.

Q: What will it take to reduce nitrate-N leaving corn and soybean fields?

A: The nitrate-N concentration in tile-flow is about the same in the corn year and soybean year when corn is rotated with soybean. In continuous corn, the concentration is higher due to the required higher optimal nitrogen rate. The requirement to apply nitrogen for optimal corn production means it would be impossible to completely reduce nitrate-N loss to acceptable levels simply through in-field practices outlined in the science assessment for the nutrient reduction strategy. It will take a suite of practices, in-field agronomic practices, crop rotation or cropping system changes, and edge-of-field treatment practices on the majority of crop production acres to reduce levels in order to meet nutrient reduction goals.

Q: What is the Iowa Nutrient Reduction Strategy?

A: The Iowa Nutrient Reduction Strategy is a voluntary, science-based plan that addresses the Hypoxia Task Force goal of reducing nitrogen and phosphorus loading to the Gulf of Mexico by 45%. The Nutrient Reduction Strategy science team, led by Iowa State University, evaluated in-field and edge-of-field practices and determined an average effectiveness for reducing the loss of nitrogen and phosphorus. A four-page publication outlining the practices identified and their effectiveness can be downloaded through the ISU Extension Publication Store.
https://store.extension.iastate.edu/Product/Reducing-Nutrient-Loss-Science-Shows-What-Works

Des Moines Water Works Processes

Q: What process does Des Moines Water Works use to remove nitrates from the river? How can they return the removed nitrates back into the river? Can the removed nitrates be land applied?

A: Des Moines Water Works monitors nitrate-N concentrations in the Des Moines and Raccoon Rivers. These waters serve as the source waters used for drinking water for the city of Des Moines and surrounding communities. The nitrate removal facility is used when the nitrate-N levels are over the safe drinking water limit of 10 parts per million (ppm). A sodium chloride-coated resin material is used to treat the source water with high nitrate levels. As the water passes through the resin, nitrate ions are captured and chloride ions are released back into the water. The nitrate that is removed from the resin is diluted and discharged back into the Raccoon River according to a National Pollutant Elimination System (NPDES) permit issued by the Environmental Protection Agency (EPA). Because the nitrate-N concentration is so low, it is not economically feasible to use the removed nitrates as a fertilizer source.

Source: Des Moines Water Works

Q: Why did DMWW need to run their nitrate removal system more frequently in late 2014 than in other years?

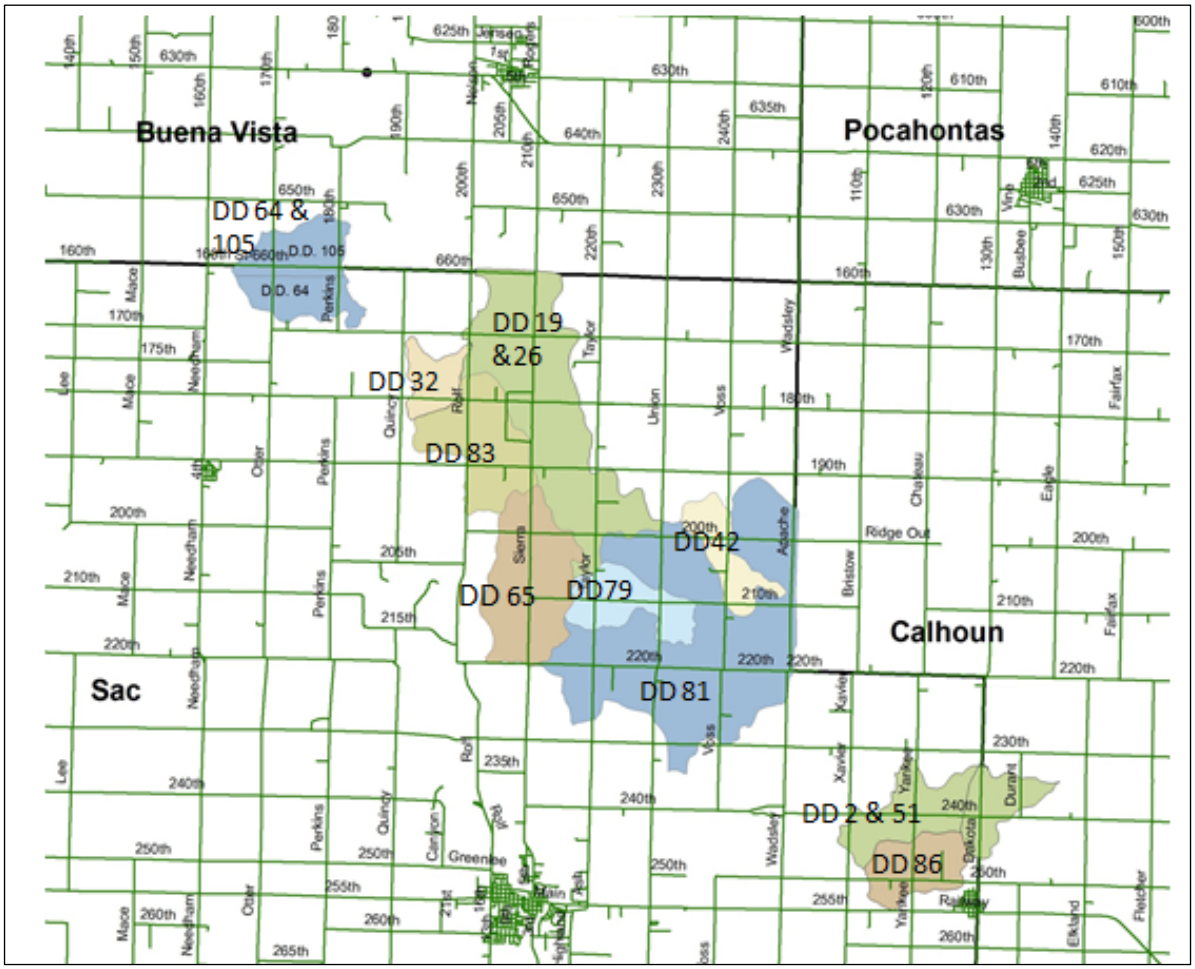
A: Iowa received higher than normal rainfall and temperatures during the fall of 2014 making conditions favorable for mineralization of N into the nitrate form. Additional rainfall caused leaching of nitrate and higher than normal levels of nitrates in the Des Moines and Raccoon Rivers. In addition, we had little surface runoff of water during this time that would have lowered the dilution rate.

Q: Why do farmers in the 3 counties targeted by the potential Des Moines Water Works lawsuit use tile drainage and what would happen if there was no tile drainage?

A: Tile drainage allows for excess water to drain away from farm fields making them suitable for crop production. Approximately 68% of Buena Vista County, 61% of Sac County, and 60% of Calhoun County cropland is tile drained. A significant area of land in each of these counties would not be as productive without the use of tile drainage.

Drainage Districts Identified in the Intent to File Lawsuit

Drainage Districts named in the intent to file letter include 32, 42, 65, 79, 81, 83, 86, and shared districts 2-51, 19-26, and 64-105.



Q: Are there watershed projects in the area currently addressing water quality concerns?

A: Watershed projects are focused efforts to improve water quality on a watershed basis. Projects involve planning, identifying natural resource concerns, education and outreach, and dedicated cost-share funding for the implementation of water quality improvement practices on the landscape. The Elk Run Watershed Project in portions of Sac, Carroll and Calhoun Counties and the Headwaters North Raccoon River Project in

portions of Buena Vista and Pocahontas counties were recently awarded funds through the Iowa Department of Agriculture and Land Stewardship's Water Quality Initiative to address nutrient loss and improve water quality**.** Watershed projects funded through other sources include:

Project Name	**County/SWCD**	**Project Type**
North Raccoon Headwaters Project	Buena Vista	MRBI*
North Raccoon River Partnership	Buena Vista, Pocahontas, Clay	MRBI*
Cedar Creek Project	Pocahontas, Buena Vista, Palo Alto, Clay	MRBI*
Black Hawk Lake Watershed Project	Sac, Carroll	WPF, WSPF, 319**

*Mississippi River Basin Initiative funding through NRCS

**Water Protection Fund, Watershed Protection Fund, and Environmental Protection Agency Section 319 of the federal Clean Water Act

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