NITROGEN LOSS?

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Really, it just had to rain large amounts in December. Seems we can't get any relief from worrying about excess rain and impacts on nitrogen (N). The questions have already begun – what about fall 2015 fertilizer and manure N applications?

A few things to consider.
It is quite hard to make an estimate of losses for such an extreme event and time of the year. Following are factors to consider that will affect loss potential, including if N was applied and if so what fertilizer product or manure source.

One, the two main N loss mechanisms are denitrification and leaching of nitrate-N (NO_3^--N). Because denitrification is mainly a biological process, and because soil temperatures were cold at the time of the recent rainfall (daily mean 4-inch soil temperatures the first two weeks of December averaged 35, 39, and 42ºF, at Caulmet, Boone, and Crawfordsville ISU research farms), denitrification will be very low. Leaching will be occurring because soils are not frozen. However, since the rainfall was intense, there was considerable surface runoff and water ponding into depressional areas. Thus N losses will be not be spatially uniform, and water movement is also occurring from depressional areas through tile drops instead of flow through soil. Also, remember that nitrate loss via tile drainage will be from residual soil profile nitrate-N after the corn and soybean crops, not just from fall N applications.

Two, anhydrous ammonia, the most common form of fertilizer N applied in the fall, forms ammonium (NH_4^+) when initially injected into soil ($NH_3 + H_2O = NH_4^+ + OH^-$). Since ammonium is positively charged, it is held on the soil cation exchange complex (which is negatively charged) and does not leach. Also, ammonium does not get biologically converted to a gaseous form. Ammonium is therefore "stable" in wet soil conditions. Manure sources containing high percentage of ammonium-N will also have considerable N initially at application in the "stable" ammonium or organic form. Phosphorus MAP and DAP fertilizer also has N initially in the ammonium form when applied.

Three, unfortunately, ammonium is converted biologically to nitrate by the process called nitrification ($2NH_4^+ + 3O_2 \Rightarrow 2NO_2^- + 2H_2O + 4H^+$ and $2NO_2^- + O_2 \Rightarrow 2\ NO_3^-$). Since nitrification is a biological process, soil temperatures have a major role in the rate of ammonium conversion to nitrate. Time is also important as the longer ammonium is in the soil, conversion will take place if temperatures are suitable for biological activity. This is the main reason suggestions are for fall applications to be made after soils cool and continue to get colder. The commonly suggested temperature is 50ºF and colder. Nitrification does not stop at 50ºF, but slows considerably below that temperature and therefore if there are not a lot of days slightly below 50ºF, the amount of nitrification in the fall will be small. All ammonium, no matter the source, will nitrify. However, anhydrous ammonia will nitrify slower than other fertilizer or

manure N sources because the anhydrous ammonia injection by itself initially retards nitrification.

Four, the most important consideration in estimation of potential nitrate loss with the recent large rainfall is how much of applied ammonium has converted to nitrate. If fall applications were made following the suggestion of <50ºF and the colder the better, then the amount of nitrate formed will be low and loss low. Conversely, if applications were made in early fall with warm soil temperatures and many days for nitrification to occur, then large amounts of nitrate could be formed. This means that earlier fall (September, October) applications will be much more at risk of loss than late fall (late November, early December) applications. However, earlier fall applications would not have all applied N converted to nitrate, just a greater fraction. As an example, in a study across three years (2011-2013, ISU Agricultural Engineering/Agronomy Farm, Boone), with application of liquid swine manure on Oct. 1 and Nov. 1 and soil sampling the injection band in late Nov. to early Dec., there was an average 137 ppm ammonium-N with the Nov. 1 application and 37 ppm ammonium-N with the Oct. 1 application. Time until cold soils will be important. Following are two-week (first two weeks and last two weeks of the month) average 4-inch soil temperatures (mid-October, end-October, mid-November, end-November, and mid-December respectively: Caulmet – 60, 52, 46, 38, 35; Boone – 59, 52, 48, 40, 39; Crawfordsville – 62, 54, 50, 43, 42ºF. You can see that soil temperatures did not get into the <50ºF range until early to mid-November depending on location in the state.

Five, effective nitrification inhibitors will help, but research has shown that nitrification is not stopped with an inhibitor, but slowed. Again, later fall application with cold soils and more recent application relative to the time of the high rainfall will help due to less nitrate formation.

Summary thoughts.
Nitrogen fertilizer or manure applications within the past couple of weeks or so should not have an issue with nitrate loss. Applications earlier in the fall will, and the earlier in the fall the greater the risk. One should not make a blanket assessment that all fall N applications have equal N losses or all applied N is gone. It is also too early to make decisions about adding more N in the spring. More prudently will be to evaluate specific situations and see how weather conditions develop next year. With soil profile moisture recharged, there is the potential for excessively wet soil conditions next spring, and that would have a greater impact on N loss than wet soils this fall.