Judith River Watershed Nitrogen Project

Newsletter #4: Sources of nitrate in shallow groundwater

This is the fourth newsletter written to provide residents of Judith Basin and Fergus Counties with information about research results from this three-year project working with local farmers. Previous newsletters reviewed alternative fertilizer use and crop rotation effects on nitrate leaching and revenue, as well as processes affecting leaching. We hope this information can help farmers develop management practices that will put more nitrogen into their crops and less into groundwater, while protecting their bottom line.[1]

TAKE HOME MESSAGES

1. Both soil organic matter and nitrogen fertilizer are important sources of nitrate that can be leached into groundwater from cultivated areas.
2. Only very small amounts of groundwater nitrate-N come from saline shales (rocks) and native range.

Primary nitrogen sources: We found that the two most important sources of nitrate in shallow groundwater in the Judith River watershed are mineralization of organic matter in cultivated fields and agricultural fertilizers. Mineralization processes can generate as much nitrate in the soil in a year as is typically applied in N fertilizer. Figure 1 shows an increase of 35 lb nitrate-N/acre in just the top foot of soil by August of the fallow year, and additional nitrate likely was produced from organic matter mineralization overwinter.

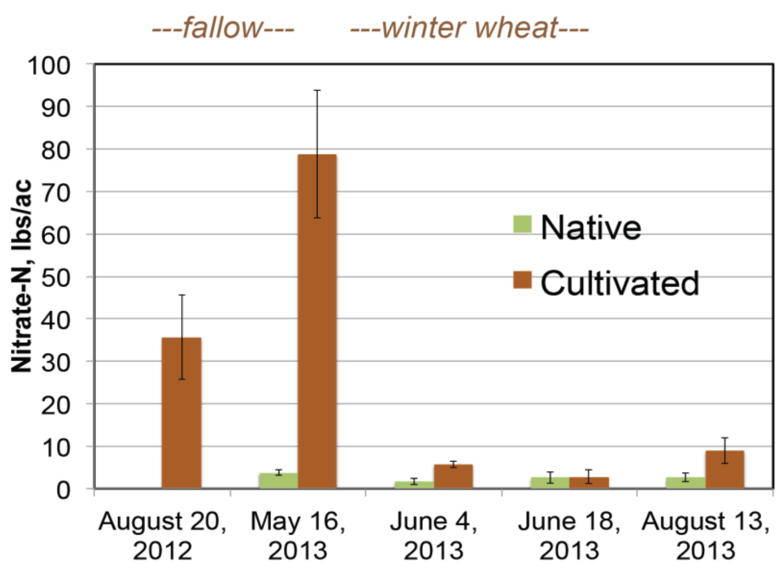

Figure 1. *Soil nitrate (top 12 inches) in a fallow-winter wheat field near Moore ("Cultivated") and in adjacent rangeland ("Native") during 2012-2013. In the cultivated field, mineralization of soil organic matter during fallow (2012) combines with soil nitrate from fertilizer addition (April 2013) to create a large nitrate inventory in May, when soil moisture is also high from fallow, and spring rainfall can leach nitrogen past young wheat plant roots. In native range, the presence of year-round vegetation and efficient use of water and nitrate keep soil nitrate levels low, limiting leaching.*

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[1] Copies of newsletters and other information can be found at: waterquality.montana.edu on the Judith Nitrogen Project website

Minor sources: Our field research also showed that native landscapes (like untilled native range) have plant communities that keep up with nitrogen produced by decomposing organic matter. While native range typically has more organic matter than cultivated soils (Table 1), most nitrate from mineralization of organic matter in native range is quickly taken up by the extensive root systems (Table 1), leaving only a small amount in the soil throughout the year (Figure 1).

Table 1. *Amount of nitrogen (N) in soil, roots and organic matter, from samples collected in August 2012 (fallow) and 2013, at a fallow-winter wheat field and neighboring rangeland near Moore, Montana.*

Land cover or crop	nitrogen in soil as **nitrate-N**	nitrogen in plant **roots**	nitrogen in **organic matter**
native range	6	220	17,000
fallow	62	0	12,000
winter wheat	13	5	12,000

--------- lbs N per acre, 30 inches --------

Similarly, the amounts of nitrate-N present in cultivated soils – particularly following fallow – far outweigh any contributions from localized saline shale formations. Using information about the presence of sodium and nitrate in groundwater, springs, and creeks, we concluded that only a small fraction (less than 10%) of nitrate-N could be derived from local shale bedrock.

Finally, we estimate that atmospheric nitrogen deposition and animal wastes are very small contributors to nitrate leaching. Although there is abundant nitrogen in the atmosphere, biological or industrial processes are required to convert it to nitrate. Also, animal wastes are not widely used to fertilize crop fields in this watershed, and the volume of nitrogen available for leaching from manure is relatively small.

Implications

Our results show that if farmers want to keep more soil nitrate and fertilizer nitrogen in their soils, rather than losing it to leaching below the root zone and into groundwater, their management practices must pay attention to nitrate pools that reflect both the addition of nitrogen fertilizer and also the process of mineralization of organic matter in the soil. Since mineralization and deep percolation (below root zone) depend on soil moisture levels, managing crop rotations to avoid situations where high soil nitrate levels occur during heavy precipitation events can be a critical part of reducing losses of nitrogen from the root zone. Managing the timing and magnitude of fertilizer applications and exploring alternatives to fallow can ensure that nitrogen in the field can be utilized by crops and maximize returns to farmers while reducing potential impacts to groundwater.