Nutrients and Water Quality Concerns

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One of the primary goals of nutrient management planning is to minimize any detrimental effects that nutrients can have on the environment. Maintaining the quality of surface and groundwater is a key concern. On livestock farms, the proper management of nutrients in manure is an important environmental issue, since managing nutrients in manure can be more challenging than in commercial fertilizer. Manure contains nutrients and organic matter that normally benefit the environment but, if improperly managed, can reduce water quality.

Concerns from Nitrates

Nitrogen in manure can be in different forms, but under the right environmental conditions, most forms will eventually be converted to the nitrate (NO_3^-) form (Figure 1). Nitrate is highly soluble, and since it is negatively charged, it is not readily absorbed by soil particles. This makes it susceptible to leaching through the soil and accumulating in groundwater. Groundwater quality can be reduced if contaminated by nitrates. High nitrate levels (>10 milligrams Nitrate-N per liter of water) in drinking water may lead to health problems such as methemoglobinemia ("blue baby"), especially in young infants. In this case, elevated nitrates in humans interfere with the body's ability to transport oxygen in the blood stream. Excessive nitrate in groundwater originating from livestock operations is possible for a variety of reasons:

- manure storage facilities are not properly sealed,
- nutrients are applied too closely to sinkholes or rock outcroppings,
- excessive nitrogen applications beyond the crop's needs,
- nitrogen application just prior to large runoff-production storm event

One purpose of nutrient management planning is to develop management practices that minimize the risk of these things happening. Due to the human health concerns from nitrates, nutrient management plans, until recently, have historically focused on managing nitrogen with little regard to other nutrients, with respect to water quality.

One major consideration in Northern Arkansas that can affect nitrate contamination is karst topography. This geographical feature is defined as limestone formations characterized by sinkholes, springs, caves, fractured rocks, etc. The concern here is that karst formations often have direct pathways from surface features to groundwater with very little treatment potential from soil. In severe cases, it can be like pouring the nitrates through a pipe directly into the groundwater or introducing them directly into a well. Much of Northern Arkansas is karst topography, and special attention needs to be given when developing nutrient management plans in this region.

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Concerns from Phosphorus

Phosphorus (P) is a naturally occurring element in the environment. It is an essential nutrient for plant and animal life. Over the past 20 years, P has become an increasing environmental concern as it can accumulate in and degrade the quality of freshwater streams and lakes. Phosphorus is not considered a human health issue, and it would not be a problem, except that P is the nutrient that limits biological activity in most of our clear water lakes and streams. Nitrogen and potash generally occur naturally in the environment in sufficient quantities to support algae and plant growth in water bodies. Insufficient P in most inland water bodies keeps the clear water lakes and streams from being congested with algae and aquatic vegetation.

The P requirement for aquatic plants is, in order of magnitude, smaller than for terrestrial plants. Very small increases in P in freshwater can trigger unwanted algae and vegetative growth. This can lead to the acceleration of eutrophication, the natural aging process of a lake that is characterized by excessive biological activity. Consequences of accelerated eutrophication include degradation of recreational benefits and drinking water quality. Excessive algal growth and decay can cause drinking water to have a foul odor and an “off flavor” taste, which raises treatment costs to correct for human consumption. Advanced eutrophication can also reduce aquatic wildlife populations and species diversity by lowering dissolved oxygen and increasing the biological oxygen demand (BOD).

Eutrophication from excessive P has not generally been considered a public health issue like other contaminants derived from agricultural runoff, such as nitrates or pathogenic bacteria. However, there are toxic algae that can flourish with increases in available nutrients, which is causing researchers to focus more attention on the isolated events that have occurred in other states.

The Fate of Phosphorus Applied to Pastures

Most forms of phosphorus are readily adsorbed by soil particles in a very stable chemical bond. For this reason, phosphorus has been considered historically to be immobile in runoff unless it moved with soil particles during soil erosion. The conventional wisdom was that if good ground cover was maintained, then phosphorus should not move and would not harm water quality. Since most non-legume forage crops require much more nitrogen than phosphorus (Table 1), nutrient management plans have been based on nitrogen needs of the crop rather than phosphorus needs.

Repeated application of manure based on nitrogen needs causes P to accumulate in the soil. In some cases, ten years of repeated application have caused very high soil test phosphorus (STP) levels, particularly on pasturelands where crops have not been removed. Phosphorus in pastures that are grazed is generally recycled through the grazing animal and deposited back on the pasture. In the

Figure 1. The Nitrogen Cycle

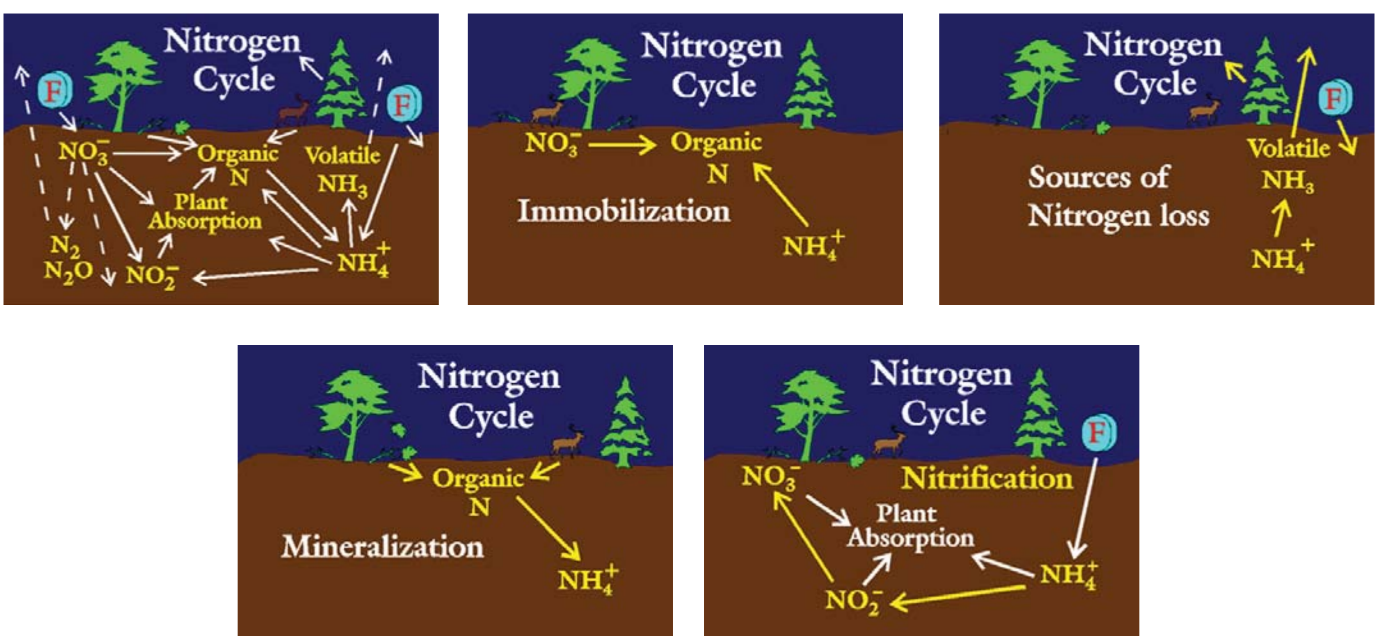

Figure 2. Research and water quality monitoring is helping to assess the impact of nutrients derived from animal manures on water quality of streams and rivers.

past, this buildup has not been a cause for concern. Phosphorus is a naturally occurring nutrient and, even at high levels, is not detrimental to crop production.

For some sites with high STP levels, it is now known that appreciable amounts of soluble P can be removed from pastures in runoff water, even in the absence of additional manure applications. Looking at the top one inch of the soil profile, recent research has shown that the concentration of P in runoff increases as STP increases (Figure 2). However, it should be noted that factors other than STP may influence P movement.

More recent research has shown that phosphorus losses from pastures can be dominated by soluble P losses from freshly applied poultry litter in runoff from storm events soon after application (Figure 3). These losses from the litter can be up to five times more than soil-derived phosphorus losses even on extremely high soil P levels.

These research findings along with water quality monitoring (Figure 4) have led to increased focus on developing and implementing management practices that reduce phosphorus inputs to streams and lakes. Reducing P in runoff from confined animal operations has become of primary concern with state and federal agencies. In fact, both new state and federal regulations that require nutrient management plans require and that these plans will be based on P rather than nitrogen.

Phosphorus-Based Nutrient Management Plans

Historically, nutrient management plans were based primarily on nitrogen to optimize forage production and to minimize nitrate contamination of groundwater. For example, most nutrient management plans written in Arkansas to date have been based on nitrogen since forage crops need much more nitrogen than P. In nitrogen-based plans, the long-term use of poultry litter as fertilizer on forages may lead to the buildup of soil P. Due to the sensitivity of water quality to P and the excessive P applications in nitrogen-based plans, nutrient management plans are now being written based on P as the first consideration.

Phosphorus-based plans do not necessarily mean that application rates will be based on phosphorus instead of nitrogen. If it is determined during the planning process that minimal environmental impact from P exists, then the application rates may well be based on nitrogen. The production ramifications of P-based application rates when using manure are that more acreage will be needed to spread the same amount of manure and that nitrogen needs from the manure itself will be insufficient to meet high production goals.

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Figure 3. Relationship between Mehlich III extractable P in captina surface soil and dissolved reactive P (DRP) in runoff (based on STP levels in the top one inch of soil). ***Source: Pote et al., 1996***

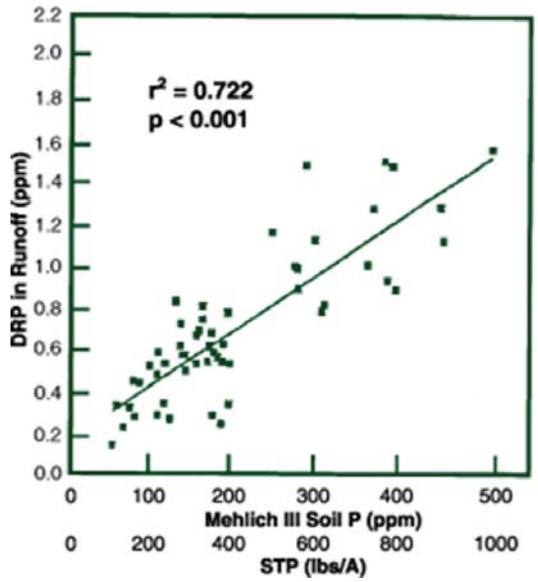
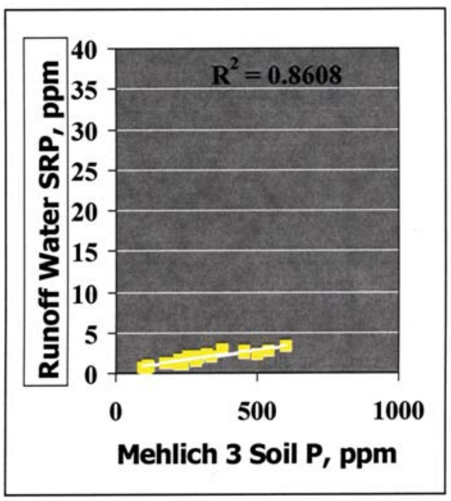
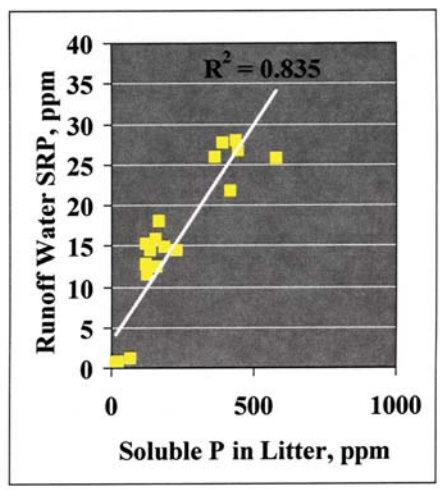


Figure 4. Comparing the losses of soil-derived phosphorus and soluble phosphorus in poultry litter from pastures. ***Source: DeLuane and Moore, 2001. Better Crops. Vol. 85(4):16-20***





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