Agriculture Practices and Nitrate Pollution of Water

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*NOTE: **BOLD** emphasis added by us at TransPak Trading*

American agriculture is noted worldwide for its high productivity, quality, and efficiency in delivering goods to the consumers. This high productivity of the American farmer is responsible for an abundant supply of food at reasonable prices. The cost of food for the American consumer is the lowest in the world. These high agricultural production levels are achieved by using plant nutrients such as nitrogen, phosphorus, and potassium as fertilizers, manures, sludges, legumes, and crop residues. **When nutrients are applied in excess of plant needs, they have a potential to pollute surface and groundwater**.

In West Virginia, contamination of surface and groundwater by nonpoint sources is of great concern. West Virginia is a water rich state, and rivers originating in this state drain into the Chesapeake Bay and into the Gulf of Mexico. With increasing concerns for the health of these two major water bodies, water quality of our rivers has received scrutiny. The Potomac River, which flows through the Eastern Panhandle of the state, is identified as a major source of nutrients (nitrogen and phosphorus) to the Chesapeake Bay.

Growers are being increasingly viewed as contributors to environmental degradation. **In recent years many reports have identified agricultural nonpoint source pollution as the leading source of water quality impacts to rivers and lakes.** The impact of agricultural practices on groundwater quality is of particular concern. This concern is heightened by the fact that a majority of the population of the state receives their drinking water supply from private wells. Most of these wells are shallow and are vulnerable to water pollution, especially from nitrate.

Many government programs are available to help people design and pay for management approaches to prevent and control nutrient losses from agricultural land to surface and groundwater. Many farmers use their own resources to adopt technologies and practices to limit water quality degradation by plant nutrients. Adoption of technologies and practices for nutrient loss reduction from farms can be promoted when farmers understand the factors that contribute to water contamination.

Many farmers apply nitrogen as fertilizers or manures to their crops. Nitrogen applied through fertilizers or manure is converted to plant-available-nitrate by bacteria living in the soil. The growing plants consume part of these nitrates. Growing bacteria also consume nitrates. When sufficient decomposable organic matter is present, soil bacteria can remove a significant amount of nitrate-nitrogen through a process called immobilization. Nitrate- nitrogen becomes a part of soil organic matter through this process of immobilization. Another group of bacteria use nitrates as a substitute for oxygen when oxygen is limited. These bacteria convert nitrate-nitrogen to gases such as nitrogen, nitrous oxide, and nitrogen dioxide. This conversion of nitrate-nitrogen to gaseous form is known as denitrification. **Nitrate-nitrogen not taken up by crops or immobilized by bacteria into soil organic matter or converted to atmospheric**

gases by denitrification can leach out of the root zone and possibly end up in groundwater.

In the United States more public water supplies have been closed due to the violation of drinking water standards for nitrate than from any other contaminant. The current public health standards for safe drinking water require that maximum contaminant level (MCL) should not exceed nitrate concentrations of 10 ppm as nitrate-N or 45 ppm as nitrate (10 ppm nitrate-N is the same as 45 ppm nitrate). When nitrate in a public water supply reaches or exceeds drinking water standards, costly measures must be taken. The well may have to be deepened or closed, another water source may be acquired for blending, or expensive water treatment may be required.

Nitrate in water is present as highly soluble salts. Standard water treatment practices, such as sedimentation, filtration, chlorination or pH adjustment with lime application, do not affect nitrate concentrations in the water. Nitrates from water can be removed by specialized water treatment technologies, such as ion exchange, biochemical denitrification, and reverse osmosis. Incorporation of these technologies for removal of nitrates into a water treatment system could substantially increase the cost of water treatment. One California water district estimated that wellhead nitrate-N treatment cost $375 per million gallons. Thus, once an aquifer is contaminated with nitrate, it will cost a large amount of money to use that aquifer as a source of drinking water. A more prudent approach is to prevent nitrate contamination of ground water. Before initiating pollution prevention practices for nitrate, knowing the factors that contribute to nitrate contamination of an aquifer is important.

Many factors should be considered when determining the vulnerability of an aquifer to nitrate pollution from agricultural practices. Nitrate contamination of ground water depends upon climate, fertilizer or manure management, soil, crop, and farming systems.

A climate with rainfall exceeding evapo-transpiration often leads to the movement of rainwater to groundwater. In West Virginia, water received though precipitation is more than that lost through evapo-transpiration from soils and plants. A part of the water received through precipitation becomes surface runoff and is lost from the land through rivers or streams. Nitrates are highly soluble salts. When water moves on the surface of a soil, it dissolves some nitrates that are present in the surface layers of soils. Another part of the precipitation seeps into the soil and recharges the groundwater. Water that has seeped through the soil is called groundwater. This seeping water dissolves soil nitrates. Any excess nitrates that are present in this groundwater-recharge zone are carried to the groundwater.

There are numerous hydrogeological settings where there is a significant hydraulic connection between a stream or a river and an underlying aquifer. Groundwater that occurs in fractured rocks in mountainous area is typically strongly connected to streams. Most of the flow in a mountain stream results from groundwater. Thus, nitrates that were initially lost through leaching to groundwater can contribute to the nitrate pollution of surface water such as streams, rivers, and lakes.

Alluvial sand and gravel deposits within the flood plain and terraces of river valleys typically function as high-yield aquifers and are commonly used to produce municipal supplies. Groundwater in these deposits typically exhibits a strong degree of hydraulic connection with the stream. Along many reaches, stream water routinely moves between the aquifer and the stream. In these hydrological settings, a nitrate-polluted stream can significantly impair the quality of the groundwater.

Nitrate leaching from fertilizer use depends upon the fertilizer types (ammoniacal, nitrate or organic), method of application, and climatic conditions. Nitrate leaching may be greater when a fertilizer contains the nitrate compared to the situations where ammoniacal nitrogen is the major component of a fertilizer. Nitrate losses are likely to be more when all the nitrogen is applied in one application compared to when nitrogen is applied in split applications. Fall-application of fertilizers or manures will cause high nitrate losses during early spring. Nitrate losses from fertilizer use can be reduced by matching fertilizer application with nitrogen needs of a crop.

Nitrogen fertilizers or manure used on a sandy soil are more vulnerable to leaching to groundwater than nitrogen used on a clay soil. Water moves rapidly through sandy or other coarse-textured soils. Nitrates move along with the water in a soil. Nitrogen loss to the groundwater from clay soils is smaller than those for the coarse-textured soils. The negative charge on the clay particles retains ammonium ions (NH_4^+). Retention of ammonium ions on clay particles protects them (ammonium ions) from leaching. Nitrate ions (NO_3^-) are negatively charged and are not retained by clay particles. Clay soils do not specifically retain nitrates. Water movement through clay soils is very slow and small. Water does not pass easily through clay soils so nitrates, which only move with water, do not leach to groundwater. Pore space in clay soils is often filled with water. Water-filled pores of clay soils lack oxygen. Lacking oxygen, a group of soil bacteria, called facultative anaerobes, substitute nitrates for oxygen for respiration. When bacteria use nitrates as a substitute for oxygen, they convert nitrates to nitrogen gas through a process called denitrification. More nitrates are lost by denitrification in clay soils than in sandy soils. Nitrate losses through denitrification in clay soils reduce the amount of nitrates that can potentially leach to groundwater.

Soil thickness and distance between the root zone and groundwater also determine the vulnerability of an aquifer to pollution. The closer plant roots are to the water table, the more readily nitrates enter drinking water. Nitrate leaching from shallow soils on fractured rocks such as limestone can cause extensive contamination of groundwater. There are numerous reports of nitrate movement to groundwater from agricultural soils in the Karst region (limestone geology) of the state. In areas of limestone geology (Karst topography), sinkholes provide a direct link between the surface-applied nitrogen fertilizers and subsurface water. Thus, areas with a shallow water table or sinkholes are more vulnerable to nitrate contamination.

Crops that are likely to increase nitrate leaching are those that have a high nitrogen requirement, have high economic value, or tend to be inefficient in nitrogen use. High-value crops, such as nursery crops, greenhouse crops, orchards, and vegetable crops, are more likely to receive high application rates of nitrogen fertilizers. Any excess nitrogen that is not used by plants may become a source of pollution.

In confined animal production systems, nitrogen is imported to the farm as feed. In these farming systems, total amounts of nitrogen generated on a farm through manure production are often more than the crop needs. Storage of manure in open fields with no protection from rain, direct discharge of manure overflow water to a stream, or leaking manure lagoons can all contribute to nitrate pollution of surface and groundwater. In an attempt to prevent leaching of nitrates, some manure lagoons are constructed with clay liners. However, most reports suggest that many of these liners gradually break down. Even when manure is leaking from a full lagoon, a small fraction of manure nitrogen is lost to groundwater as nitrates. The water passing through a full lagoon loses all its dissolved oxygen because of bacterial activity. In the absence of oxygen, organic nitrogen from manure is not converted to nitrate. An empty lagoon is more likely to pollute groundwater than a full lagoon. Dried conditions in an empty lagoon permit organic-nitrogen from the leftover manure to come in contact with oxygen rich water.

Thus, organic- nitrogen is converted to nitrate nitrogen. As rainwater accumulates in an empty lagoon, it leaches dissolved nitrates to groundwater.

Nitrate pollution of surface water and groundwater can take place from barnyards or feedlots. Nitrate pollution is more likely to occur from an abandoned feedlot than from a feedlot that is continuously in use. In an actively used feedlot, compaction by animal hooves reduces the water that can seep through the soil. Less nitrates are lost from an active feedlot because additions of - fresh manure through animal excretions maintain a reducing environment (an environment - deficient in oxygen) that does not permit transformation of organic nitrogen to nitrates.

Although nitrate pollution from agriculture has received a lot of attention**,** many private wells have been polluted with nitrates due to misuse of fertilizer on lawns that were close to shallow water wells. Mismanagement of fertilizer nitrogen is more common in urban areas. This misuse results from lack of knowledge of the relationship between excessive nitrogen use on home lawns and groundwater pollution. Urban sources of nitrate pollution have received less scrutiny because total amounts of nitrogen fertilizer used in urban areas is small compared to that used in agricultural areas. While the total nutrient load from urban areas is small, it contributes more nutrients on a per acre basis and can have significant impact on local water quality.