Effects of Animal Waste on Groundwater: 
Including a Focus on Nitrogen

Introduction
To keep up with increasing consumer demands for animal products, scientists are finding ways to improve the efficiency of animal growth by feeding additional ingredients to livestock and by growing large numbers in concentrated areas. Recently though, other scientists are finding that these procedures may have harmful effects on human health, when nutrients from animal waste seep into the ground surrounding concentrated animal feeding operations (CAFOs). Once these chemicals are in the ground they seep into the soil and then into crops and human drinking water.

Recent Developments
Managing waste from CAFOs can be costly for farmers and to dispose of it many have been spreading waste from their facilities across pasture or crop land. Lagoons have become a common treatment method for animal feeding operations and hold large amounts of animal waste coming from these facilities. The purpose of lagoons is to brake down animal waste in order for it to be useful as compost and fertilizers, or for landscaping projects (Huang & Lee, 2001). Waste lagoons normally use a procedure that includes two to three descending pools, in which the waste is slowly transferred from the upper pool to the lower. By the time waste reaches the lowest pool it should be diluted by the added water and bacterial action (Aillery et al., 2005). It has been found that insufficiently lined or overflowing lagoons make it possible for nutrients to seep into the soil and end up in groundwater.

Effects on Human Health
Some of the chemicals being discovered in the soil and groundwater near these production farms include arsenic, nitrates, phosphorus, organic matter, and pathogens (Aillery et al., 2005). Most of these chemicals are not harmful unless humans are exposed to amounts that a body cannot use for basic management.

Arsenic is a toxin and a known carcinogen, while nitrogen and phosphorus in surface water will increase algae growth in rivers and streams, degrading aquatic life (Hubbard, Newton, & Hill, 2003). Excess intake of nitrogen has also been found to be the cause of Blue Baby Syndrome in infants under a year of age (Hubbard, et al., 2003). Other harmful effects have been attributed to prolonged exposure to organic matter and pathogens which can cause cancer and birth defects.

General Methods and Procedures
Much research has been done to prove that under certain circumstances animal waste has had a negative effect on groundwater. A study conducted by Huang and Lee (2001), observed that dissolved organic matter (DOM) from animal waste that leached from lagoons, had the potential to bind with some pesticides already in the ground and carry them throughout the soil.
The binding ease of DOM to pesticides could be due to the fact that liquid animal wastes have, according to Fernando, Xia, and Rice (2005), “a relatively higher ionic strength, higher concentrations of major cations and anions, and a higher pH compared with a normal soil solution” (p. 1057). When pesticides latched on to DOM moving through the soil they eventually made it into ground and drinking water. If the DOM is properly held within the lagoon until the time it is deemed usable for commercial purposes, that is, the nutrient concentrations have been reduced by dilution, then it will be less likely to bind with fertilizers in the ground and contaminate drinking water (Haung & Lee, 2001).

More about Nitrogen

Out of all the nutrients being discovered in groundwater, nitrogen seems to be one of the most commonly studied and problematic. This could be because of its abundance or because nitrate poisoning can be lethal to a person or animal if intake exceeds recommended amounts.

Nitrogen gas, in its natural form, is a vital part of our world and makes up 78% of the atmosphere. Nitrogen becomes problematic when it is converted to one of its reactive forms which are: ammonia, ammonium, nitric oxide, nitrogen dioxide, nitrate, and nitrite (Aillery et al., 2005). According to Spruill, Showers, and Howe (2002), in 1962 the United States Department of Health, Education, and Welfare set the standard for nitrate found in drinking water to a maximum of 10 mg/L of nitrate as nitrogen and remains at that number today.

As previously mentioned, nitrate can easily run into groundwater because its ions do not allow it to be absorbed by soil (Hubbard et al., 2003). When nitrogen, in the form of nitrite, is consumed by man or animal in excess it can prevent oxygen flow in the blood stream, potentially causing death. Nitrite doesn’t have enough time to transform into ammonium when someone or something consumes excess amounts. This causes hemoglobin to convert into methemoglobin, the cause of reduced oxygen flow.

Fernando et al. (2005) found that “ammonium accounts for almost 99% of the soluble nitrogen in animal waste” (p. 1057). When ammonium is not properly diffused throughout soil it can fall victim to the nitrification process; a procedure carried out by bacterium that converts ammonium into nitrite (Fernando et al.).

Nitrogen Research

Even though it has been proven that excess amounts of nitrogen can be harmful to humans and animals, it is still being found in abundance at or near animal feeding facilities. The Spruill et al. (2002) study found that $^{15}$N nitrate was useful in distinguishing animal sources of nitrogen from soil organic nitrogen and fertilizer nitrogen. This differentiation process is an important step in determining how to rid soils of animal sources of nitrogen while keeping the organic sources of nitrogen present.

It was found in a North Carolina study spanning a five year period that pumping lagoon waste water into wetlands can be useful in separating ammonium and nitrogen (Szogi, Hunt, & Humenik, 2003). Further advances such as these would be beneficial in that farmers could gain control over animal waste management and prevent a problem from developing.
Positive Effect of Animal Waste

If animal waste is managed correctly it can have some positive effects. According to Hubbard et al. (2003) ground nutrients in low concentrations can be easily absorbed by forages, reducing the risk of groundwater contamination. Organic matter from animal waste “can improve the quality of water” Hubbard et al. said, “by improving the water-holding capacity in the soil, decreasing energy needed for tillage, and by increasing the population of beneficial organisms that live in the soil such as earthworms” (p. E257).

These ideas are only applicable if animal waste distributed throughout pasture or crop lands is in low concentrations and if there is a large amount of absorbable vegetation to prevent nutrients from getting into drinking water. Hubbard et al. (2003) provided evidence of this theory by recognizing studies that used riparian forests surrounding animal feeding facilities to catch the nutrients traveling out of these operations.

Solutions

Much is being done to preserve water quality in the United States. The United States EPA adopted a set of rules in 2003 which require CAFOs to have vegetation buffers surrounding their facilities. These rules were set up in hopes that the vegetation would absorb most of the nutrients before they are pulled into ground water by runoff and erosion (Hubbard et al., 2003). In 2003 the EPA also revised the Clean Water Act in hopes of reducing the amount of animal waste nutrients running off into surface and ground water (Aillery et al., 2005).

More is being done to find out how much water contamination is caused by animal waste leaching from lagoons. Spruill et al. (2002) said “nitrate $\delta^{15}N$ data in combination with other water quality variables, such as ions or ionic ratios, may be effective in distinguishing animal sources” (p. 1539). A procedure such as this could be beneficial in the future for using techniques that will fix the waste management problem seen in and around CAFOs.

Conclusion

Recently animal feeding advancements have taken a toll on groundwater quality in the United States. Excess amounts of animal waste have been found to cause an overload of nutrients in the ground and water surrounding contaminated sites. The impact of CAFOs on groundwater contamination depends on how well the facilities and waste operations are managed.

Facilities and waste lagoons need to be built durable enough to prevent nutrients from leaching into the soil and groundwater. According to Szogi et al. (2003), “when land demographic conditions are limiting, other waste management systems are needed that will reduce the contamination hazard of water resources by concentrated livestock wastewater” (p. 1943). More research is needed to find different techniques to fix the animal waste management problem, or to prevent it from being a problem before a facility is built.

Audience

Scientists interested in research pertaining to the effects of animal waste on groundwater quality in the United States would benefit most from the information in this research brief. A basic understanding of CAFOs, nitrogen, and ammonium is needed to understand this material.
References


