PURDUE

ANIMAL ISSUES

Briefing

Hypoxia in the Gulf of Mexico: A Reason to Improve Nitrogen Management

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Knowledge to Go

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Situation

• An area of low oxygen (e.g., hypoxia) in the waters of the Gulf of Mexico forms every summer, and it has been increasing in size since 1993. The zone reached 7,000 square miles in 1997. The hypoxic zone lowers fish and shellfish densities, and threatens one of the nation's most productive fisheries.

• Most oceanographers agree that nutrient loading increases the potential for oxygen deficiency to occur in fresh and marine systems. In fresh water, phosphorus is limited, while in marine systems, nitrogen is limited. In both cases, nutrient addition stimulates algae growth. Once the algae die, an aggressive microbial population that also uses up all of the available oxygen in the water consumes them. This oxygen reduction is the root of the hypoxia.

• Most oceanographers agree that nutrient loading, particularly nitrogen, contributes to the formation of this oxygen deficiency in marine systems. In fresh water, phosphorus is limited, and additions of the nutrient cause increased algae productivity and hypoxia. In salt water, nitrogen rather than phosphorus is usually the limiting nutrient.

• The Mississippi River, which drains 40% of the land area of the contiguous 48 states, including most of Indiana, is responsible for carrying most of the nutrients into the Gulf of Mexico. In fact, the amount of nitrogen transported into the Gulf by the Mississippi and the adjacent Atchafalaya has more than doubled since 1960.

• Concern about the hypoxia zone—and its effect on the fisheries—has greatly increased awareness of the importance of nitrate discharges throughout the Mississippi River watershed. Since agriculture is one of the major sources of nitrate in the Corn Belt, management practices related to nitrogen use are expected to come under increased scrutiny.

What We Know

• Nitrate in the Mississippi River comes from point sources such as industrial and sewage treatment plant discharges, and nonpoint sources such as agriculture and urban runoff. Nitrogen is also deposited directly from the atmosphere in precipitation. However, nonpoint sources, particularly agriculture, appear to be the major contributors of nitrogen.

• The nitrogen balance for agriculture is complex. Nitrogen inputs to the land include fertilizer, manure, nitrogen in precipitation, and mineralization of nitrogen from organic matter in the soil. Loss mechanisms may include plant uptake, volatilization, denitrification, storage, and application losses of manure nitrogen. Over the long term, the excess of nitrogen inputs over outputs is lost to surface or ground water.

• Tile-lines discharge significant quantifies of nitrogen (in the form of nitrate) into ditches and rivers in Indiana and elsewhere. Studies at two sites in Indiana showed typical nitrate-nitrogen concentrations from tile-lines of 20-30 ppm. Total nitrogen lost through tile-lines ranges from 20 to 75 lbs per acre each year. For a 100-acre field, this is not only an economic loss for the farmer of up to $1500 (assuming replacement nitrogen cost of 20 cents per lb), but the addition of 2,000 to 7,500 lb. of nitrogen to surface waters.

What We Don't Know

Environmental Processes Controlling Formation of Hypoxic Zones

• We don't know what effect decreased nitrogen in the Mississippi would have on the hypoxic zone and how long it would take for such an effect to occur.

• We don't know what nutrient levels are desirable to maintain the health of the Gulf of Mexico ecosystem.

• We don't know the role of river channelization in the hypoxia process. Efforts to make the river more navigable have destroyed wetlands which helped to clean drainage waters entering the river. The loss of such areas, where sedimentation, nutrient transformations, and other microbial processes took place, may play a significant role in determining the amount of sediment and other contaminants loading in the gulf.

• We don't know the effect of the balance of other materials flowing to the Gulf. For example, a reduction in sediment may contribute to hypoxia if it reduces silica, because the growth of certain types of algae appears to depend on the nitrogen/silica ratio. An additional potential contributor to the hypoxic zone may be organic chemicals released to the river from point and nonpoint sources.

While scientists continue to research these issues, it does appear that reducing levels of nutrient losses from Indiana agriculture would be beneficial for maintaining the Gulf of Mexico's fisheries and ecosystem as well as the long-term health of Indiana's rivers and lakes.

Variables Affecting Nitrogen Use and Loss

• We cannot know the precise amount of nitrogen that crops will use during a certain year, and therefore, although management can be improved, farmers will probably never be able to add only the precise amount of fertilizer needed at the beginning of a season. Farmers should always take credit for the nitrogen in any added manure, as well as the 15-20 lbs of nitrogen that typically fall in rainfall in Indiana. Basing nitrogen applications on a realistic crop yield goal can significantly reduce the amount of nitrogen lost to tile-lines and streams.

• We don't know the precise effect of management practices that reduce nitrate leaching, but we do know that winter cover crops, controlled application rate, split application with proper timing of applications, and the use of nitrification inhibitors can help to reduce nitrate flow in tile drains.

• While restricting the drainage outflow from tile lines in winter months (controlled drainage) can significantly reduce nitrate loss, we don't know exactly how these will work under Indiana conditions or how to manage this for both optimal yield and denitrification.

Thus, even a strong commitment to improving nitrogen management will not completely eliminate nitrogen losses from agriculture, because many variables affect nitrogen use and losses in the field.

What We're Doing

• Purdue University is evaluating movement of nutrients through soil into subsurface drains at two sites. The Southeast Purdue Agricultural Center (SEPAC) site in Jennings County began in 1983, and the Water Quality Field Station (WQFS) in Tippecanoe County began in 1993. Monitoring at both sites shows nitrate present in all subsurface drainage water, especially from November through May or June. Research includes studies on timing of nitrogen applications and split applications approaches.

• A watershed-scale water quality study of an agricultural area in Tippecanoe, Warren, and Benton counties (the Indian Pine watershed) has found that mean nitrate concentrations in streams typically range from 1 ppm to 28 ppm, but have reached as high as 80 ppm in one stream. Current efforts focus on the use of wetlands and other best management practices to manage nutrients.