# FARMING IN THE MISSISSIPPI BASIN, FISHING IN THE GULF OF MEXICO

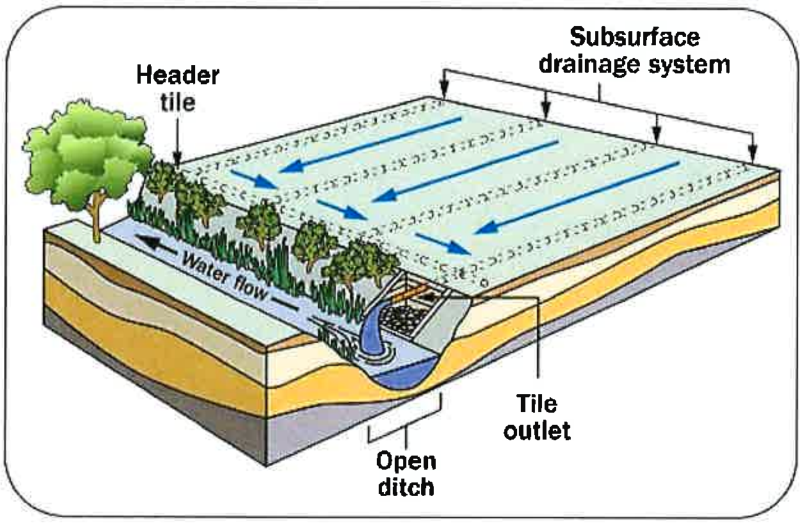
**by Steve Beeman, September 29, 2021**

Agricultural productivity has increased dramatically over the past 80 years, primarily due to improved fertilization, land drainage, mechanization and genetic engineering. In the Mississippi River Drainage Basin, much of that productivity is in the form of corn cultivation. The Mississippi Basin covers 41% of the continental United States, roughly 1,245,000 square miles, and accounts for 80% of the nation's corn and soybean crops. It also contributes 90% of the fresh water entering the northern Gulf of Mexico.

The demand for ever increasing corn production largely derives from the 2005 U.S. Energy Policy Act which set ambitious goals for the utilization of renewable fuels, substantially supplied by corn starch. According to the National Corn Growers Association, only about 10% of the 94,000,000 acres of corn planted each year is for food consumption. Approximately 15% is exported to other countries and the vast majority is used for ethanol production and livestock feed.


Corn fields with vegetated buffer strips

A common practice in the past was to alternate annual crops of corn and soybean. Nitrogen fixation by soybeans replenished nitrate levels in the soils that were depleted by rotational corn crops. Due to the high demand for corn and the availability of inexpensive nitrate fertilizers, many farmers have discontinued soybean production. Over much of the Mississippi Basin, 90 to 95% of the landscape is devoted to intensive agriculture, primarily corn cultivation. Large areas that were not initially suitable for growing corn have been hydrologically modified by the channelization of headwater streams and subsurface tile drainage. Marginal lands, with high water tables, are drained by a network of underground pipes that channel the water vertically out of the root zone and then horizontally into collection ditches.




Tile Drainage System Schematic

Courtesy: Ontario Ministry of Agriculture, Food and Rural Affairs

An unintended consequence of modifying millions of acres to improve corn production is the export of tons of nutrients to the Gulf of Mexico each year. Water soluble and bioavailable nitrates and phosphates migrate vertically with groundwater through the soil to drain tiles, where they are concentrated and deposited into lateral ditches. In a 2015 study in Illinois, David, et al reported nitrate losses from corn fields between 20.5 and 27.3 pounds per acre per year. The nitrate concentrations in the drainage water ranged between 14 and 18 mg. per liter (parts per million).

Subsurface Tile Drainage

Photo: Todd Royer

Nutrient enriched water travels through agricultural ditches to creeks, ponds and streams. Those tributaries empty eventually into the Mississippi and Atchafalaya Rivers and the Gulf of Mexico. Mississippi Basin waters cover the coastal Gulf waters with a turbid, fertile, corn fed solution that produces massive algae and phytoplankton blooms.

The biomass created by the blooms dies and decays, feeding a population explosion of bacteria, and consuming oxygen from the water column. The resulting hypoxic area or “dead zone” affects fish and invertebrate populations in large coastal areas of the Gulf of Mexico. The National Oceanic and Atmospheric Administration (NOAA) has been studying and measuring the Gulf anoxic zone since 1985. The size and location of the “dead zone” varies annually, depending on weather conditions, hurricanes, droughts and rainfall patterns. The 2017 anoxic zone was the largest on record, covering 8,776 square miles. That means that 5,616,640 acres of shallow marine habitat was virtually sterilized that summer. During July 2019, all of Mississippi’s 41 Gulf beaches were closed due to cyanobacteria blooms. The toxic algae posed substantial health hazards to humans and animals.

Mississippi turbidity plume
Enters the Gulf of Mexico

Photo: Nancy Rabalais

So, can the nutrient loads leaving the Mississippi River Basin be reduced? Can we maintain corn production and sustain the fish, shrimp and oyster populations in the Gulf of Mexico at the same time?

So far, the nutrient reduction programs that the United States Department of Agriculture (USDA) have encouraged and funded haven't worked very well. Many agricultural Best Management Practices (BMPs) are well intended, but are difficult to install on a scale that would result in meaningful reductions of nutrients reaching the Gulf. Another issue is that all agricultural BMPs are voluntary. There are no regulations that require farmers to reduce the impacts of their operations downstream. So BMPs to reduce agricultural discharges need to be beneficial to farmers, or at least not prohibitively expensive.

Let's take a look at some of the current BMPs for agriculture:

Constructed wetlands: This is an edge-of-field approach, designed to capture drainage water and reduce nitrate losses through denitrification and plant uptake. Constructed wetlands initially result in nutrient reduction but plant uptake is reversed when the plants die during winter months.

Edge of field buffer strips: The effectiveness of buffer strips is greatly reduced during cold weather, when the native plants die or go dormant. Also, in tile drained fields, the nutrient rich water enters the drainage ditches below the root zone of the buffer strips.

Woodchip Bioreactors: These are simply trenches filled with wood chips that use the process of microbial denitrification to remove nitrate from runoff water. Their effectiveness is determined by climatic conditions, since the input and outfall elevations are set. Drought or flood conditions determine residence time and therefore treatment time. During flood conditions, treatment is substantially reduced.

Drainage water management: This technique involves the construction of water control structures in tile drained fields to retain water during the non-growing season and reduce nutrient losses. The glaring flaw in this approach is that water flows laterally to adjacent fields that don't have control structures. Even if water is successfully retained for the duration of the off season, the nutrients are still present when the controls are removed at the beginning of the growing season. At best, this is a short term nutrient storage measure.

I'd like to offer a suggestion for another BMP option that has the potential to significantly reduce nitrate and phosphate losses from corn fields. It can be deployed in existing tile drainage ditches during the growing season. It doesn't require additional land, and accommodates fluctuating seasonal water levels. The excess nutrients in the water flowing from the discharge pipes can be utilized to grow secondary crops. Floating treatment wetlands are managed aquatic plant systems (MAPS) that are portable and adaptable. They can be placed in narrow ditches, wide canals, small ponds or large lakes. They are cost effective and efficient, permanently removing nutrients from agricultural runoff.

January 2009

July 2009

Beemats Floating Treatment Wetlands in an agricultural ditch draining cabbage and potato fields
Average nitrate concentration in the water – 1.02 mg / L ; uptake rate – 260 gN / $m^2$ /yr.

Beemats floating treatment wetlands are active biological systems that remove nitrates and phosphates from surface water. They use hydroponically growing plants to extract biologically available nutrients from agricultural drainage. The leaves and the roots, with attached biofilm, accumulate and store soluble nutrients in in the plant tissues.

One intriguing feature of MAPS is the possibility of growing secondary crops in tile water ditches, using the excess nitrates and phosphates before they create problems downstream. Dr. Sarah White at Clemson University has been studying Beemats floating wetlands for thirteen years. Her earliest studies (2008, 2009 ), in controlled, circulating systems documented 58% – 83.5% nitrate removal and 45% – 75% phosphate removal.

In 2013, Clemson studies explored the possibility of growing commercially viable plants in Beemats, including basil and swiss chard. Basil removed 246.01 g N / m$^2$ / yr. ( 2,194 lbs. N / acre / yr.). Drainage water from corn fields in Illinois, as reported by David,et al (2015), with similar nitrate concentrations, discharged 27.3 pounds of nitrate / acre / year. At that rate, one acre of Beemat grown basil could take up the nitrate lost from 80 acres of Illinois cornfields. We have also grown romaine and butterhead lettuce in Beemats with similar results.

In areas where it's not practical to grow hydroponic crops for human consumption, grasses, legumes or other herbaceous species can be grown for use as livestock feed.

Lettuce Beemat

Sweet Basil

Butterhead Lettuce

In 2017, the U.S. Natural Resources Conservation Service, a branch of the Department of Agriculture, reported that it had spent over $29 billion since 2009 on voluntary agricultural BMPs. Much of the funding is provided by the Environmental Quality Incentives Program (EQUIP). Farmers may receive 75% of the cost to implement measures that reduce erosion and nutrient runoff from their fields. Although the agency claims that the cooperative programs have been successful, most researchers looking into nutrient impacts from agriculture believe that the current practices are having negligible impacts on downstream environments. It has been estimated that only about 6% of the country's 2 million farmers are participating in nutrient reduction programs at any one time. In order to significantly reduce nitrate and phosphate loading to the Gulf of Mexico, most of the fields surrounding the streams and rivers in the Mississippi River Basin would need to adopt some sort of edge of field or end of pipe remediation practice.

Since most of the current USDA supported BMPs require construction or loss of production areas, it is unrealistic to expect implementation on a large enough scale to significantly improve water quality on a voluntary basis. Almost all farmers are environmentalists by nature. They understand their role as stewards of the earth. They want to grow crops efficiently, to use all of the bioavailable nutrients in their fields for productivity, not lose them downstream. There will always be nutrient losses to drainage ditches, but the opportunity to use that rich water doesn't have to be wasted. The concept isn't complicated. Plants need nitrate and phosphate to grow and some species are efficient at extracting them from water. Why don't we diversify our crop production and clean up the water in the process. If we're going to help farmers establish BMPs, let's give them tools they can incorporate into existing water features.

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