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On-farm practices to minimize harmful algal blooms in ponds

(for the purpose of the double-blind, peer-review process, author names are not included in the initial submittal)

Ponds, which are essential source of water on farms for crop irrigation and livestock consumption, are threatened by rapid algal growth triggered by several factors. This publication provides on-farm practices that can help mitigate the occurrence and impacts of harmful algal blooms in ponds.

Introduction

Rainfall and runoff fate impact various aspects of watersheds and water quality within ponds (Figures 1 and 2). Water quality impacts depend on a variety of factors within the watershed, including but not limited to soil moisture levels (wet or dry), presence of vegetation, buffer zones, slope characteristics, soil health, temperature, livestock, agriculture, urban or rural settings, and nutrient levels. These factors collectively influence the frequency, timing, and severity of algal blooms in ponds that receive drainage from the watershed.

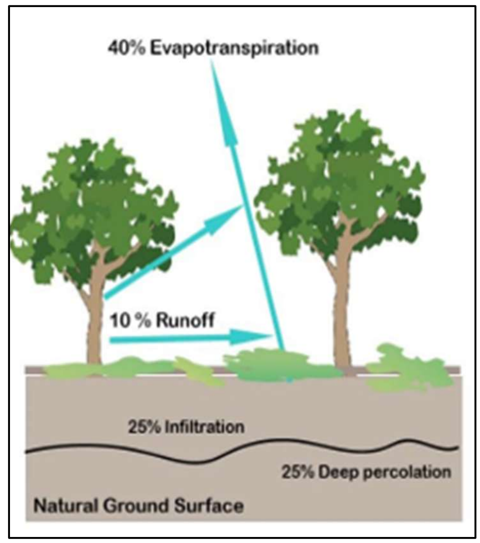

Figure 1: Some components of hydrologic cycle (modified from Busari et al. [1])

Figure 2: An agricultural pond used to meet agricultural water demand for different commodities. (Photo Credit: Debabrata Sahoo, Clemson University)

Ponds may serve various purposes, such as livestock watering or irrigation (as illustrated in Figure 2). In particular, the presence of nutrients, especially phosphorus, along with favorable environmental conditions, can affect the dynamics of algal growth and the production of toxins associated with harmful algal blooms (HAB). HABs that are capable of producing cyanotoxins are commonly dominated by specific genera of cyanobacteria, notably *Microcystis* and *Dolichospermum* (formerly *Anabaena*).

The conditions within a watershed are critical factors driving potential for HABs, but it is important to note that severe weather events, such as high-intensity storms followed by periods of drought, can exacerbate the occurrence of blooms. These weather patterns can lead to the flushing of excess nutrients into the pond system through runoff events, contributing to the development and severity of these blooms.

Nutrients, primarily phosphorus, typically find their way into a pond from the surrounding land through two primary pathways. Firstly, phosphorus typically binds to soil particles and is transported in runoff as soils erode. Secondly, nutrients can be dissolved and transported in water. In the case of soil erosion, nutrient movement occurs over-land, while when nutrients are dissolved, movement occurs either on the soil surface or via infiltration downward through the soil profile, eventually reaching the groundwater. Under certain conditions, phosphorus can also detach from the soil and dissolve into the water column. Understanding when and why soil erosion occurs is crucial, as various land management practices can be used to limit the movement of soil, nutrients, and water from the land into the pond. These practices can play a pivotal role in water quality management and overall environmental conservation.

Soil erosion is a process by which the top layer of soil is removed or displaced from one location to another through air, water, or human activities. Soil erosion is affected by several factors, such as the land cover, soil exposure, erosive power of the rainfall, soil type (i.e., how suspectable the soil is to erosion), the length and steepness of the slope, land management practices, and erosion control practices. Several land management techniques (e.g., livestock management, land management, in-pond management) can be implemented to reduce erosion and mitigate soil and nutrient movement from land to water. The practices are described below.

Figure 3. Evidence of soil erosion from relatively small areas of bare soil along roadway ditch. Image credit: Heather Nix, Clemson University.

Suggested On-Field Practices

Vegetate bare soil: Small patches of bare soil can release substantial sediment over time (Figure 3). To prevent erosion, cover soil with plants, mulch, or other protective materials (e.g., gravel). Native grasses, which can be grown from seed, offer effective erosion control. Once established, these indigenous plants thrive in the local climate, often requiring minimal maintenance.

Fertilizer application: Fertilizers fuel vegetation growth, including HABs. Apply the appropriate fertilizer rate according to the label and soil sample results. Also, calibrate application equipment prior to fertilizer application to minimize potential for fertilizer losses to runoff or leaching.[4] Factor in local weather and crop requirements, including seasonal needs, and avoid pre-storm applications to reduce runoff risk.

Irrigation: Use efficient irrigation methods on pastures and farmland to lower the potential for nutrient loss from the soil. Excessive irrigation can saturate the soil, making it more susceptible to nutrient leaching during rain events. Irrigation-induced erosion can result in greater nutrient losses than those attributed to natural rainfall.[4]

Crop rotation and cover crops: Crop rotation involves cultivating various crops on the same land during different seasons, aiming to effectively use nutrients at varying root depths, reduce nutrient runoff and provide coverage to the soil, while adding organic matter overtime. Cover crops also serve protect against soil erosion, improves water infiltration, regulates soil moisture, and enhances soil permeability, thereby mitigating nutrient leaching and losses. There are several cover crop options available in the market, and the choice of species should be based on adapted species to the area. A viable option to be incorporated are legumes once they can help incorporate nitrogen as a residual for the next crop to be grown in the area, while also contributing to increase soil fertility and quality overtime.

Conservation tillage: Maintaining a 30% crop residue cover on the soil surface curbs erosion, cuts nutrient losses and leaching, and boosts soil infiltration. Conservation tillage is a cost-effective strategy to minimize nutrient losses and enhance soil fertility and health overtime.[5] It should complement other farm management practices to mitigate nutrient runoff into water bodies and be aligned with best management practices for the operation.

Use of perennial grass systems: Perennial grass systems are a viable option to contribute to soil conservation, nutrient retention, carbon sequestration and improved soil fertility overtime. The use of perennial species eliminates the frequent need for land preparation, therefore, if well-managed, grass stands are able to develop strong root-systems that help securing soil and nutrients from runoff and leaching due to the proper land coverage year-round. Grass stands may serve as filters to reduce the transport of soil particles into waterbodies and help with reduced chances of water contamination and nutrient overload that can lead to low water quality and algae blooms. The proper management of the forage stand will be essential to provide the benefits mentioned, and guarantee that it will support the delivery of ecosystem services.

Contour farming and strip cropping: Cultivating sloping land along contour lines and planting crop strips at field edges reduces erosion, minimizes runoff, and enhances soil infiltration. This approach is suitable for fields with gentle to moderate slopes.[3]

Grass swales: Grass swales are vegetated depressions designed as linear water conveyance structures, serving as natural water treatment features (Figure 4). Swales are cost-effective to install and incorporate baffles to decrease water flow and enhance water quality by capturing sediment and nutrients.

Figure 4: Grassed swales minimize soil erosion and nutrient losses (Photo from NRCS photo library)

Filter strips: These are structural features (Figure 5) that use vegetation to reduce water flow speed and prevent the movement of sediment, nutrients, and contaminants through settling and infiltration. Filter strips slow water flow, facilitating the settling of sediment and contaminants and encouraging nutrient absorption by plants. They are typically positioned along field edges or the edges of waterways; they are most effective on slopes under 10% and can remain functional for quite a few years with proper upkeep.[6]

Fencing livestock from waterways: Concentrated livestock movement over a prolonged timeframe can lead to vegetation degradation and erosion, raising sediment and nutrient levels in waterbodies. Fencing livestock out of waterbodies, streams and ponds protects banks, reduces threading impact, and preserves shorelines.[7] Locations for livestock to access water can be integrated with pond fencing, limiting access to less than 5% of the water body (protecting 95–100% of the area). Financial support may be accessible for waterway fencing through USDA Natural Resources Conservation Service (NRCS or South Carolina Department of Health and Environmental Control (SCDHEC), Section 319 grants in eligible watersheds. Reach out to your local Extension agent for help.

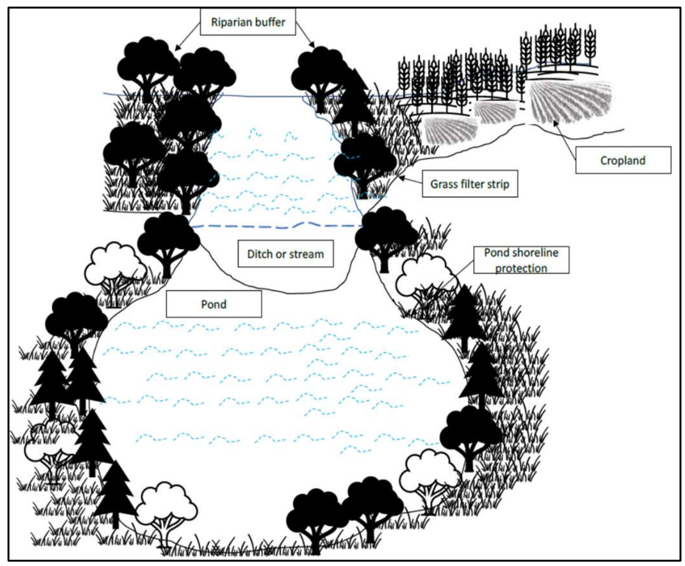

Figure 5: Combination of land management practices (sourced from Nix et al. [2])

Riparian buffer: Vegetated zones of trees, shrubs, and grasses (Figure 5) near streams or along pond shorelines safeguard against erosion, bank sloughing, and excess nutrient runoff into the pond. Buffers provide diverse ecological benefits within the watershed and can help reduce non-migratory waterfowl presence, further reducing nutrient inputs.

Constructed wetlands: Constructed wetlands installed at agricultural operations effectively treat on-farm nutrients and can also offer wildlife habitat and ecosystem services. The water is routed slowly through these systems to get maximum treatment.

Forest: Integrating trees into land used for livestock operations offers multiple benefits, including reduced erosion and nutrient losses to the pond, and improved livestock performance by mitigating heat stress. Optimal forest placement is key.

Economics of nutrient removal technologies: There are a variety of technologies available to treat nutrient-contaminated ponds. Some technologies include aerated constructed wetlands (CW), floating treatment wetland systems (FTWs), and biofilters using carbon materials such as woodchips. The specific costs can vary depending on the choice of technologies and other operational factors (e.g., the scale of ponds, land slope, and the level of concentration). However, generally, aerated CW technology can require high upfront costs with its capital investment compared to FTWs and woodchips. FWTs have the lowest capital costs but may come with high operating costs for plant maintenance; however, costs can be reduced by selling the plants for fodder production or ornamental plants.[8,9] Overall, FTWs can be the most cost-effective for pond water management.

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