Using Pond-Wetland Systems To Treat Greenhouse Runoff

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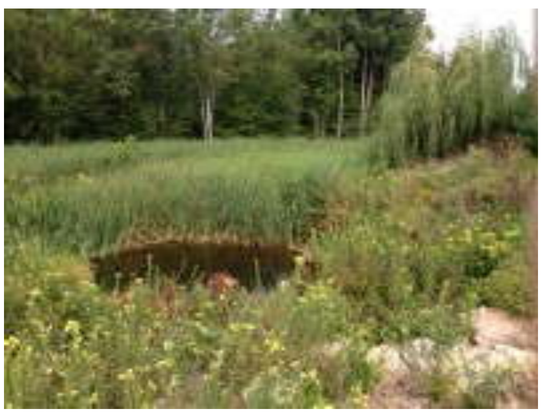

Regulations governing agricultural runoff have become more stringent in recent years. Greenhouse agriculture is not exempt. Greenhouse growers often employ sophisticated fertilizer and irrigation systems that can greatly limit discharge, but high production rates and

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year-round production capabilities increase the need to properly manage runoff. Drainage from greenhouse irrigation and overflow from ebb and flow storage reservoirs typically contains fertilizer nutrients and a mix of pesticide residues.

The Right Systems To Treat Runoff
Systems used to treat agricultural runoff vary with the type of application. These may range from simple vegetated ditches, sometimes referred to as bioswales, to more elaborate systems supporting a complex web of biological activity. Constructed pond-wetlands are built to provide a diverse biological community capable of reducing or degrading the concentration of pesticides or other chemicals, nutrients and/or turbidity in surface runoff.

The **Environmental Protection Agency (EPA)**'s Guiding Principles for Constructed Treatment Wetlands defines constructed treatment wetlands as, "engineered or constructed wetlands that utilize natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist, at least partially, in treating an effluent or other water source."

While natural wetlands support biological processes capable of treating agricultural residues, most states have regulations restricting the contamination of state waters. This prevents the use of natural wetlands as part of a treatment system.

For the purpose of runoff management, the systems within the greenhouse plus the adjacent constructed wetland and the collection ditches linking them together can all be defined as part of the extended agricultural system. Once the water leaves this system, however, it becomes state waters and must be acceptably clean of fertilizer and chemical residues.

These systems have a variety of design elements and each plays a role in treating runoff. Specific design elements take different forms. For example, various elements sizes and the type of vegetation can vary.

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The specific design will depend on the desired capacity and the type of pollutant or waste in the runoff. Variations of these systems are commonly used for both agricultural and urban purposes. In an animal feedlot application, the concern is mitigating nitrogen, phosphorus and animal waste, whereas in a parking lot application, the concern is oil and other petroleum residues, heavy metals and road salts.

Constructed Pond-Wetland Systems

All such systems, regardless of design or complexity, have certain common elements. Water carries residues into the system, and the flow is slowed down and diluted in volume. Then it travels slowly through several diverse features (deep pools, shallow pools, plant systems, gravel or sand beds). Plants, microbial communities, and physical forces work to degrade, bind or neutralize nutrients and chemical activity.

The essential biological elements in these systems include soil, water, plants (from algae to higher vascular plants) and aerobic and anaerobic bacteria.

Physical factors, such as sunlight, chemical properties (pesticide toxicity, half-life, solubility, binding properties, concentration, etc.), loading rates and residence time in the system, also affect the removal efficiency in these systems.

The Components In The System

Each of the essential biological elements plays a specific role in the ecosystems to reduce contaminants in the runoff. Here is a quick rundown of how each of these components work.

Soil: Sediments (turbidity) in the inflow settle out at the plunge pool as water velocity slows. Soil particles and organic matter bind to some nutrients and chemical agents, including some pesticides and plant growth regulators, such as triazol compounds like Bonzi. The sediment provides contaminate storage that is import for chemicals that degrade slowly. Sediments lining the pond also provide microbial attachment. Sediments support

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many of the living organisms (biota) that degrade pesticides and remove nutrients.

The permeability of the soil substrate affects the movement of water through the bacterial rich layer, and many chemical and biological transformations take place within the substrate as part of the soil food web. Finally, decaying vegetation from wetland plants adds organic matter to the substrate, which supports the diverse biological community in the system.

Microbial action: Microorganisms are largely responsible for the degradation of organic chemicals in these systems. While most biological action occurring in a constructed wetland is anaerobic, both aerobic and anaerobic bacteria contribute to these systems.

Aerobic bacteria thrive in surface water and in biofilms associated with plants, whereas deep, slow-moving pools and the underlying sediments support anaerobic bacteria. This microbial action converts or transforms many pollutants into insoluble or harmless substances and increases the processing capacity of the wetland sediments to remove pollutants. Microbial action is also a major contributor to the cycling and retention of fertilizer nutrients in the constructed wetland ecosystem.

Plants: Vascular plants (plants that grow high above the water surface or subsurface) and non-vascular plants (algae) are important to these systems. Photosynthesis by algae increases the dissolved oxygen content of the water, which affects the nutrient and metal reactions. Vascular plants stabilize sediments and minimize channel flow, thus slowing water flow. This allows the heavier suspended particulates to settle out and increases the residence time in the system. Vascular plants take up carbon, nutrients and metals, such as essential plant nutrients like iron, zinc, copper, etc., as well as removing some heavy metals like lead.

Water: Water supports biological life, including plants, animals and microbes. Water also serves as a carrier, channeling runoff thru the system. The relative large

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volume of water in pond systems also serves to dilute the concentration of runoff entering the system. This makes it easier to reduce contaminant levels to acceptable thresholds.

For example, a 1-ppm concentration of a pesticide in 100 gallons of runoff becomes 1 ppb in a 100,000 gallon pond and 0.1 ppb in a 1 million gallon pond. Many systems are designed with a large water storage feature, and most systems are designed with a bypass or overflow feature as well. During storm events, flow through a system will be rapid, resulting in reduced breakdown or binding of pollutants. In such events, concentrations will still be greatly reduced by dilution.

In addition to the biological elements, a number of physical factors influence the system's efficiency at neutralizing contaminants. Sunlight will degrade some chemical compounds. Open water zones allow sunlight to penetrate, facilitating this process.

Of all the variables that affect the removal and degradation of pesticides, hydraulic retention time in artificial wetlands is the primary factor in the performance of the biological treatment. Simply put, the longer the flow path, the slower the movement through the system, resulting in a more complete removal of pollutants.

Retention time can be increased by using a series of connected systems, repeating design elements or using baffles, channels or berms to lengthen the flow path.

Pond-Wetland System Effectiveness
Published studies provide some guidance. In one example of a wetland system covered with phragmites, retention rates of 90 percent between the inlet and outlet were reported for the aqueous-phase insecticides chlorpyrifos (Dursban) and endosulfan (Thiodan). Particle-associated insecticides, chemicals that bind to soil, were retained in the same wetland at almost 100 percent.

In research conducted on the fate of pyrethroids

introduced into slow-flowing vegetated ditches, more than 99 percent reduction was reported over a 50-yard course. Removal efficiency of nutrients in biofiltration ponds reportedly range from 28 to 90 percent for total nitrogen, 65 percent for nitrate, 40 to 100 percent for total phosphorus and 80 to 95 percent for total copper and zinc.

Greenhouse runoff mitigation is complex because we crop year round and use many different types of materials (PGR, fertilizers, insecticides, fungicides). When designing a system for a greenhouse operation, it is further complicated by the fact that acceptable environmental threshold concentrations have not been determined for many of the minor-use compounds applied in the industry.

In the absence of acceptable discharge thresholds, system design capacity can be based on commonly used compounds that have established thresholds, such as nitrate-nitrogen, and some of the widely used pesticides that are common to outdoor farming applications.

In developing design specifications for a greenhouse, you need to know the concentration and volume of the chemicals in the discharge, the properties of these compounds and the regulatory tolerance levels for final discharge into state waters.

For greenhouse producers, limiting the concentration and volume of runoff is a good first step. You can do this by following best management practices (BMPs) for greenhouse irrigation. If your state has not developed BMPs, the ones provided by the U.S. EPA are a good guide. (Find a link at GreenhouseGrower.com/October2012)

Things To Remember

Closed irrigation systems like ebb and flow systems offer many of the features recommended by the EPA. However, the fate of stored water at the end of a crop can still be an issue, and there can be other liabilities associated with these systems. Excess nutrient solution from the end of one crop cycle can sometimes be used as a feed for a second crop. This is not always feasible due to disease concerns, but when possible, it reduces the need to discharge.

One liability with using flooded floor and bench systems that recycle water is that excess irrigation from overhead baskets can exceed the capacity of storage tanks, necessitating periodic discharge. Additionally, pesticides that land on the growing surface are picked up in the irrigation water and can accumulate in the recirculation tank. As a result, you may have a cocktail of PGR and pesticide residues — usually at low concentrations of a few ppm or ppb — when you are ready to discharge.

Wastewater management is now an important part of the agricultural enterprise. Greenhouse producers need to adopt technologies that not only limit waste in production, but also reduce or degrade discharge to the environment. Linking the biological cleansing power of a wetland ecosystem to the agricultural enterprise is one way to achieve this goal.

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