Engineered wetlands provide community benefits and treatment for industrial wastes

By Mark Liner

Treating industrial wastewater is a complex and often costly matter. Finding new methods that take a natural approach can enable companies to accomplish environmental clean-ups and provide potential assets to communities. Industrial treatment wetlands, with their simple mechanics, ease of operation, and low maintenance costs, are becoming a leading choice for high quality treatment and remediation in a number of industries. Waste streams from airport deicing operations, concentrated feed lots, landfills, and other contaminated sites are all candidates for this natural treatment, while complying with strict environmental regulations.

What makes this approach even more enticing is the rate of acceptance by surrounding communities. This is due to the potential to integrate these industrial wetlands with community amenities such as recreational areas, nature centers, trail networks, and natural habitats that the residents can enjoy.

How does it work?

A wetland cell can be rigorously engineered to be a stand-alone treatment process or it can be coupled with other processes (like lagoons) to augment performance. Because water levels are controlled in these systems with impermeable liners and specific placement of influent and effluent points, the system's performance can be controlled like an engineered reactor.

Subsurface wetlands are filled with gravel media, which is cleaned and sized to optimize hydraulic treatment. The loading rates of the wetlands are established so as to exploit bacterial growth while minimizing impacts on the subsurface hydraulics. An aeration system is installed at the bottom of the gravel that creates an aerobic zone within the wetland where water is recirculated to optimize treatment. Mulch is used for insulation.

With these various control measures, what may seem to be a passive, uncontrollable technology actually has a process schematic similar to advanced sewage plants. This design flexibility allows for engineered wetlands to treat a wide spectrum of pollutants.

Lowering ammonia to benefit water reuse

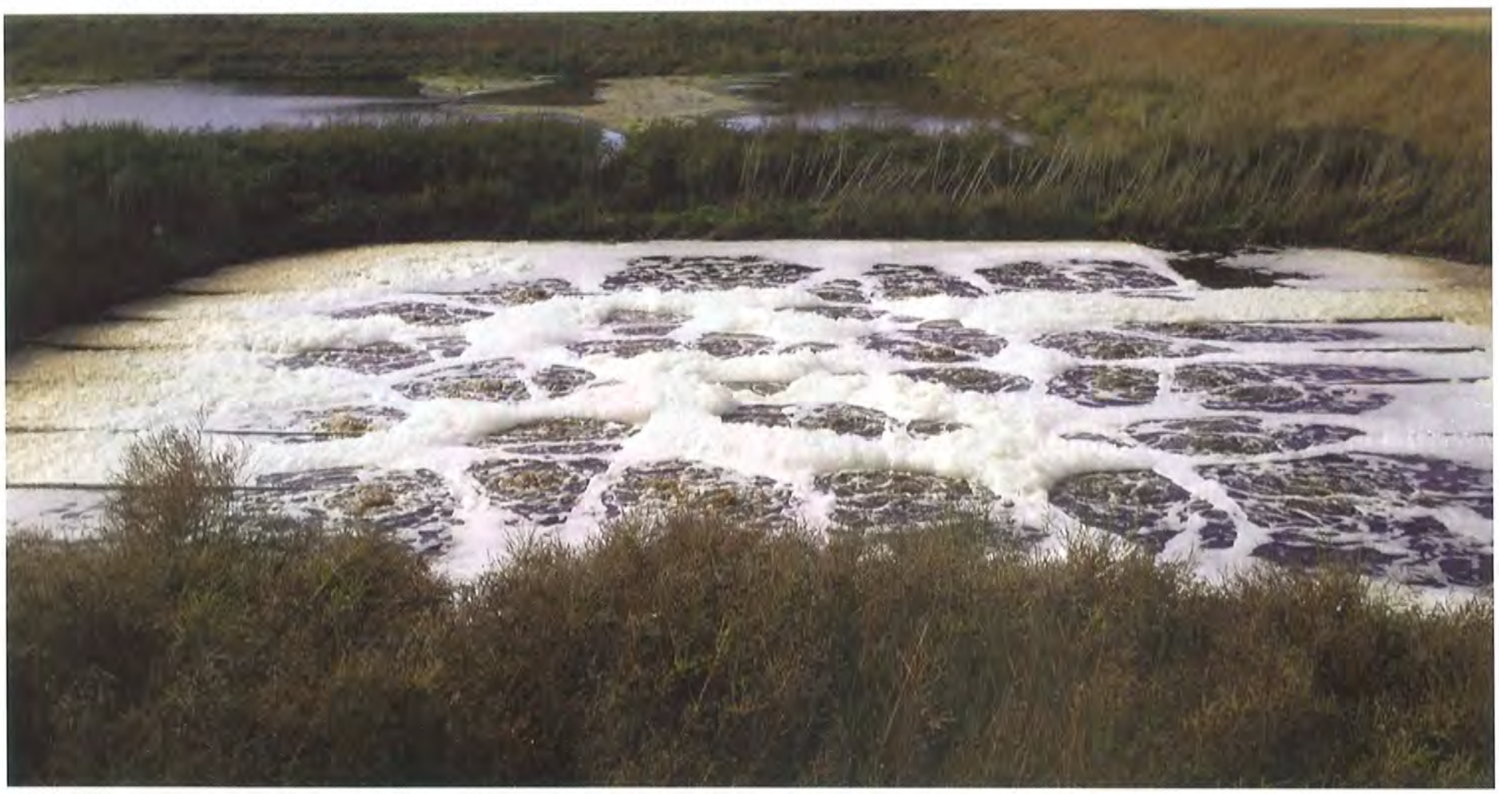
Farms have long been involved with cradle-to-cradle practices for managing wastes. Feed is produced from the field crops, animals eat the feed and generate manure, and manure is returned to the fields for crop production – a virtuous and sustainable nutrient cycle. Wastewater reuse is also commonly practiced. Christensen Farms of Sleepy Eye, Minnesota, owns and operates a number of farms in the Midwest. Like many livestock production facilities, Christensen Farms reuses water at the facility. To improve the quality of water for reuse, farm managers contracted with Jacques Whitford NAWE to create a wetland-based tertiary treatment system.

In the Christensen Farms wetland treatment system, earthen storage basins at four farms were re-engineered with tertiary treatment designed to reduce nitrogen levels in the reuse stream. Supernatant from the anaerobic lagoons is discharged to a pre-aeration cell for pretreatment. Following this, flow is introduced into a free-water surface wetland designed to polish the water and provide a natural habitat for water fowl. Treated water is pumped from the wetlands and reused for barn washwater.

Engineered wetlands for glycol removal

Another innovative use of engineered wetlands for industrial wastewater treatment is the use of subsurface, aerated

The wetland system provides tertiary treatment for the Christensen Farms.



gravel beds to treat stormwater contaminated with glycol from airport deicing operations. These engineered wetlands are currently under design for Buffalo Niagara International Airport (BNIA). The below-grade beds are designed to sustain a resident, attached community of bacteria acclimated for the specific task of glycol removal. The stormwater is distributed uniformly over the beds and flows vertically through the gravel to a system of underdrains. Air is pumped to the beds through a network of aerating tubing. The bed is insulated on top with a layer of peat mulch, which has been proven to be an important means to conserve heat.

Key to executing the design was the successful off-site treatability testing of propylene glycol-spiked stormwater from

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Airport managers are looking at wetlands for treatment of deicing fluid.

Subsurface flow constructed wetland near completion at former BP site. The wetland is being covered with a tan mulch layer to ensure cold-weather operation during the winter months.

the airport. Pilot work at wetland test facilities was conducted to evaluate the performance of the system and to determine process kinetics. The results of the pilot-scale testing determined that there was very good treatment (96 - 97% removal of target pollutants) at both the high and low design basis temperatures.

Ultimately, the wetland will consist of eight wetland cells excavated from an existing open area near the airport's main runway and will encompass roughly 10 acres. At ground level, only a field of wetland grasses will be observable, growing from a "dry" mulch surface. An important factor of the design is the size of the gravel used and the porosity of the bed. Detailed analysis of biomass growth, storage, and decay was undertaken to ensure that the bed could seasonally accommodate the transient nature of the bacterial community.

Wetland use in landfill leachate treatment

Due to the variable nature of landfill leachate, a treatment system must be able to receive and properly treat a wide range of parameters over a wide range of concentrations. For this reason, a complete leachate system must include a number of unit processes that target removal of a certain group of parameters.

Wetland treatment systems are used in concert with other processes to completely treat a full range of leachate parameters. In particular, wetlands are used for bacterial-mediated degradation of some of the more difficult to degrade organics. Aerobic and anaerobic zones can be engineered in the wetland to expedite the degradation of xenobiotic compounds. Subsurface wetlands with properly sized gravel media provide a stable surface for attached growth bacteria, which allows the bacteria to be resident in the wetland and acclimate to the variable load.

For the Anoka County Landfill in Minnesota, a bioremediation system was designed for 288,000 gallons per day of leachate-contaminated groundwater. The design included eight 50,000 square-foot horizontal subsurface flow wetland treatment cells. In order to provide year-round treatment, the wetlands are insulated using energy balance design methods. Use of mulch as an insulation layer on subsurface wetlands has proven effective in permitting cold weather operations of wetlands. Forced bed aeration is also employed within the wetland cells to create alternating aerobic/anaerobic zones for degradation of complex organic compounds, including tetrahydrofuran.

Detailed pilot work on an engineered wetland has also been conducted at the Jones County Landfill, Anamosa, Iowa. The pilot is designed for the remediation of up to 500 gallons per day of landfill leachate and is operated as a research facility by the University of Iowa Department of Civil and Environmental Engineering. Results from the pilot have focused on the ability of the wetland to treat for ammonia during cold weather and have dramatically illustrated the benefits of wetland aeration.

Engineered wetlands used for petroleum remediation

Treatment for benzene, toluene, ethylbenzene, and xylene (BETX) occurs through volatilization and aerobic biodegradation. The microbial communities in wetlands have been proven to break down many of these and other volatile organic compounds that are associated with petroleum products. The challenge is to engineer a system that provides the right and consistent environment to allow such microbial communities to flourish. In these cases, an aerated, subsurface wetland is an effective, stable means for achieving BETX degradation.

A wetland system implemented by British Petroleum (BP) in Casper, Wyoming, is the largest and most recent remediation wetland in the United States. This treatment system needed to handle up to 3,000,000 gallons per day of gasoline-contaminated groundwater, blend into the middle of a premier golf course, and operate for over 100 years. The site includes an office park, river front trails, and a whitewater kayak course.

The system includes a cascade aeration system for iron oxidation and air stripping, a soil-matrix biofilter for gas-phase benzene removal, surface flow wetland cells for removal of ferric hydroxide precipitates, stormwater retention wetlands, and radial subsurface flow insulated wetland cells for BTEX removal. Support of the design required conducting a pilot, which permitted the derivation of site-specific rate constants. Also, nonequilibrium gas/liquid benzene phase change calculations were necessary in addition to the heat balance.

Conclusion

To most, wetlands are a wet piece of land with plants. To an engineer, a wetland is a complex reactor that facilitates numerous chemical and biological reactions, and these reactions can be exploited to remove pollutants. For remote facilities, engineered wetlands can provide a valuable, low maintenance treatment system that can be easily constructed on-site. Using state of the art techniques, wetland engineers are able to create systems that effectively clean up the dirtiest of wastewaters – from landfill leachate to spent deicing fluid.

Environmental managers and engineers are looking for treatment solutions that work for the long haul. Designing systems to handle future flows with lower life cycle costs is a goal in most cases. Engineered wetlands deliver on this goal and integrate the treatment necessary into the facility, often enhancing the site for plants, animals and people.

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