Constructed Wetlands for Landfill Leachate Treatment

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Constructed wetlands treat a wide variety of wastewaters and runoff waters using emergent plants. Free-water surface (FWS), subsurface flow (SSF), and vertical flow (VF) constructed wetlands all use a combination of fixed-film biological activity and physical, chemical, or photochemical mechanisms. The treatment of landfill leachate is one particular application for which constructed wetlands have been used widely (Crites, et al., 2005).

While all types of constructed wetlands have been used to treat landfill leachate, VF wetlands have been most successful, particularly for ammonia reduction. These wetlands are two-to three-foot deep sand beds that are underdrained, and have bulrush or reeds on the surface. Leachate is collected into a storage tank from which it is pumped to the wetlands. Periodic or intermittent dosing onto the wetlands often lasts for an hour followed by five hours of resting. To accommodate this intermittent application, the site is divided into six sub-basins; one is wetted while the other five are drying.

Vertical flow wetlands recently planted with bulrush in Salem, Oregon.

A combination system utilizing a VF wetland bed followed by an FWS wetland has been used to treat landfill leachate at various sites in Indiana. In some cases the leachate is applied directly to the wetland; in others the leachate flows to an equalization pond, from where it is transferred to the wetland unit. A wetland at the Escambia County landfill in Florida is aerated to reduce the organic loading from septage that is also added to the pond.

Design and Siting Factors

Leachate composition depends on the type and quantity of materials placed in the landfill and on the time since placement. Thus, characterization of the leachate is essential for proper wetland design because it can contain high concentrations of biochemical oxygen demand (BOD), ammonia, metals, high or low pH, and possibly priority pollutants of concern. In addition, the nutrient balance in the leachate may be inadequate to support vigorous plant growth in the wetland and supplemental potassium, phosphorus, and other micronutrients may be necessary.

Typically, the wetland will be sized to achieve a specific level of ammonia or total nitrogen in the final effluent. This may be accomplished with a single FWS or VF wetland or with a series of VF cells. As an example, a VF wetland recently designed to treat 15 gallons per minute of landfill leachate required approximately one-half acre.

Because leachate is collected from the subsurface of the landfill, the treatment wetlands are usually sited downgradient from the landfill or the leachate is pumped to the wetlands.

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Constituent	Influent	Effluent	% Removal
pH, units	6.32	6.86	--
TSS, mg/L	1,008	30	97
TDS, mg/L	1,078	396	63
COD, mg/L	456	45	90
TOC, mg/L	129	17	87
Copper, mg/L	0.05	0.024	52
Lead, mg/L	0.078	0.004	94
Mercury, mg/L	0.0019	0.0019	0
Nickel, mg/L	0.082	0.01	88
Zinc, mg/L	0.08	0.03	62

Removal efficiency of FWS constructed wetlands treating landfill leachate (from Johnson et al., 1998).

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agreements to provide habitats for some species of endangered native fish.

Another method, used in many mosquito-control districts in the country, is to introduce into the wetland a non-native fish, usually a species of *Gambusia* (more commonly called mosquitofish). *Gambusia* feed on mosquito larvae; however, they also have a tendency to feed on smaller fish, including some of Arizona's endangered native fish! Use of *Gambusia* therefore has not been encouraged. In an interesting twist, without Tucson Water's knowledge, someone recently stocked the gazebo pond at Sweetwater with *Gambusia*.

Be Vigilant!

In the Southwest, when the potential for standing water is high, we must be prepared to monitor for mosquitoes and act when appropriate. Vegetation grows, debris accumulates, water flows change. It may take a few years, but sooner or later, mosquito problems will emerge in any wetland or even in recharge basins if good maintenance is not practiced. In Southern California, one constructed wetland had the distinction of being the primary source of mosquitoes capable of vectoring western equine encephalitis for an area of approximately 23 km^2 (Walton, 2002) until its structure was changed. Vigilance is important.

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Wetlands also can be constructed in modules as the landfill is built out.

Other Factors: BOD, Ammonia, and Climate

Atmospheric exposure and the relatively long hydraulic retention times of the wetlands options result in very effective removal of the volatile priority pollutants. If the leachate BOD is consistently above 500 milligrams per liter (mg/L), then the use of a preliminary anaerobic pond or a VF wetland cell should be considered.

For landfill leachates with high ammonia content on the order of 300 mg/L or more, VF wetlands are usually required because they facilitate transfer of oxygen into the wetlands. These wetlands can be combined in series or with recirculation to treat high ammonia concentrations because they can transfer oxygen from the atmosphere into the sand where nitrification can occur. Intermittent dosing of VF wetlands (alternately wetting and drying) is similar in concept to using recirculating sand filters (Crites and Tchobanoglous, 1998).

Some advantages and benefits of the SSF wetland concept, such as preventing public contact with the wastewater, are not necessary at most landfill locations, so an FWS wetland may be a more cost-effective choice even if it requires more land. The exception may be in cold climates, where the thermal protection provided by SSF wetlands offers an operational advantage. The table on page 29 shows the performance of an FWS wetland treating landfill leachate in Mobile County, Alabama.

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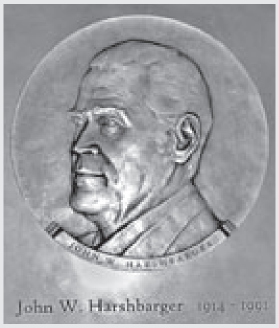
PEOPLE

Harshbarger Honored at UA



The late John W. Harshbarger was honored in November by the University of Arizona's Department of Hydrology and Water Resources. David R. Hargis, founder of Hargis + Associates consulting firm and a former student of Harshbarger, presented a bronze plaque at the ceremony, which was placed on Harshbarger's namesake building that houses the hydrology department.

Harshbarger joined the faculty of the geology department at the university in 1955, becoming head of that department six years later. He was instrumental in creating the hydrology department in 1966, and was its first chair.

Harshbarger was a geologist with the U.S. Geological Survey prior to arriving at the University of Arizona, and he built an active relationship between that agency and the new department. He also developed close ties with the Water Resources Research Center, which was established around the same time as the hydrology department.

Harshbarger's research and experience was diverse. He worked in the mining industry, exploring for uranium and vanadium. He was involved in the Manhattan Project. He initiated the first water resources survey of the entire Navajo Nation, and in 1966 he published *Arizona Water* (USGS Water Supply Paper 1648), a non-technical survey of Arizona's hydrology and water resources. Harshbarger eventually started his own consulting company in Tucson, where he worked the last two decades of his life, primarily in the area of groundwater development.

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