Article 97

Technical Note #76 from Watershed Protection Techniques. 2(2): 372-374

Vegetated Rock Filter Treats Stormwater Pollutants in Florida

In recent years, a growing number of communities have employed rock or gravel-based media to grow emergent wetland plants to treat domestic wastewater. Known by many names, including rock-reed filters, vegetated submerged bed (VSB) wetlands, and shallow horizontal flow wetlands, they all apply the same basic technique (Figure 1). Wastewater is introduced into a shallow cell of rock or gravel in which wetland plants are rooted. Flow then travels slowly between the pore spaces in the rock, where it is subject to settling, algal and wetland uptake, and microbial breakdown. A recent technology assessment suggests that, when designed properly, VSB systems are a reliable and promising technique for reducing sediment, nutrient and organic carbon levels in wastewater (Reed, 1995).

In contrast, most stormwater wetlands are designed only to treat surface flows (and not subsurface flows). The question naturally arises whether the inclusion of rock or gravel cells could increase the pollutant removal performance of stormwater wetlands. Some preliminary answers have been recently reported by Egan and his colleagues (1995) in Central Florida. They designed and constructed an experimental "stormwater treatment train" to treat runoff from a 121-acre industrial subwatershed to protect a sensitive lake from eutrophication. The off-line system featured packed bed filter cells. Each packed bed filter cell was excavated into the soil, and had dimensions of 80 feet wide by 30 feet long and three feet deep. The bottom of each cell was sealed with a plastic liner, and then filled with either crushed concrete or granite rock. Eight filter cells were planted with one or more of the following emergent wetland plant species: maidencane, giant bulrush, and fireflag. Two cells were not planted to serve as controls, i.e., to test the pollutant removal capability of the rock media itself.

The packed bed filters were but one component of a larger treatment train. The first component was an off-line storage facility designed to capture the first flush of runoff from the watershed. Diversion weirs shunted the water quality volume into a sedimentation chamber to provide pretreatment. Next, runoff was diverted into one of 10 packed filter beds cells. Flow into each cell was regulated by submersible pumps that distributed runoff evenly into each cell at one of three flow rates: 0.067, 0.13 and 0.27 cfs (or about 0.1 to 0.5 acre-feet of runoff treated per cell per day). The experimental system was instrumented with automated sampling monitors, and 15 simulated storms were withdrawn from the sedimentation chamber during the spring and summer.

The overall pollutant removal performance of the packed bed filter system is summarized in Table 1. It should be noted that the mass removal reported does not include any prior removal that may have occurred in the sedimentation chamber that supplied runoff to the filter cells. As can be seen, the removal rates for total suspended solids, total phosphorus, and fecal coliforms all approached or even exceeded 80%. In addition, the removal of both inorganic and organic nitrogen was

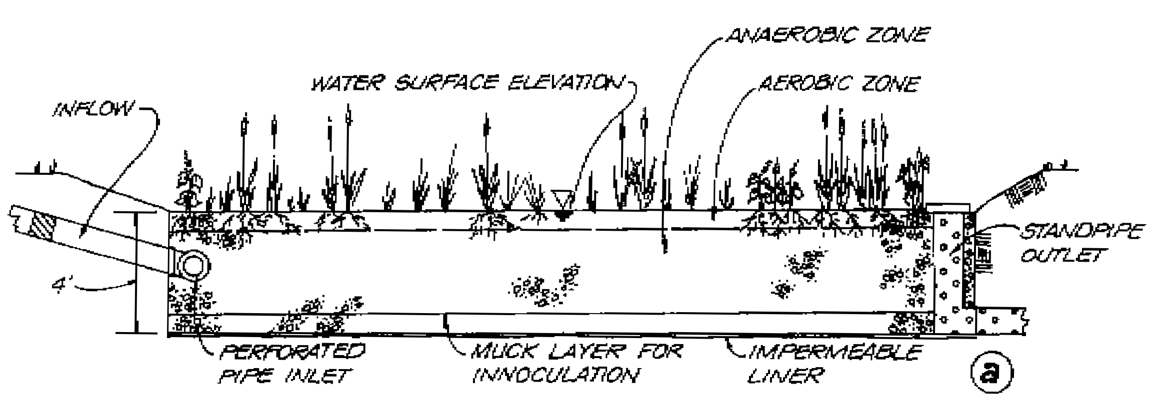

Figure 1: Schematic of a Vegetated Submerged Bed Wetland System

significant, ranging from 60 to 75%. In particular, the high removal of nitrate is unusual for many filtering systems, and may indicate that both nitrification and denitrification were occurring in the aerobic and anaerobic environments of the rock filter cells. Removal of other pollutants was moderate (organic carbon) to low (ortho-phosphorus and total dissolved solids). Removal of metals was also variable, with low to moderate removal for metals often found in soluble form (copper and chromium), and moderate to high removal for metals found primarily in particulate form (cadmium, lead and zinc). The metal removal analysis was somewhat complicated by the fact that many incoming metal concentrations were often at or below detection limits. In general, the pollutant removal performance of the packed bed filter was similar to those reported for sand and compost filtering systems, with the notable exception of consistently higher removal rates for inorganic nitrogen.

The 10 packed bed cells were arrayed in a manner that allowed Egan to examine the comparative influence of different rock media, wetland plants and flow rates on overall pollutant removal capability of the system. The statistical analysis revealed some interesting and surprising trends. For example, filter cells filled with recycled crushed concrete performed better than those that used granite rock. Egan speculated that the higher pH of concrete (7.5 versus 6.9) may have promoted greater epilithic algae and bacterial growth. In addition, the unplanted crushed concrete cells performed better than any other planted cells, suggesting that wetland vegetation had no discernible influence on pollutant removal. Emergent wetland plants did appear to slightly improve the performance of granite rock cells. The surprising conclusion, however, was that the rock surfaces themselves were more important in pollutant removal, by creating a large substrate area for growth of epilithic algae and microbes, reducing flow rates, and providing more contact surfaces. The same conclusion was reached by Reuter and his colleagues in their analysis of a sub-surface gravel-based wetland system in colder climates. Lastly, Egan and his colleagues found that best performance was achieved at the highest rate of flow, which tended to draw down water elevations in each cell by a third.

The experimental study implies that gravel or concrete filter cells could be an effective enhancement to surface stormwater wetlands designs, particularly in coastal regions where greater and more reliable nitrogen removal may be desired. In most cases, the basic design may need to be modified to allow gravity-driven flow rather than mechanical pumping. Where sufficient head is available, storm flows could be routed through a series of wetland or sand filter cells, and then into a sub-surface rock or gravel wetland cell. To prevent clogging or sediment deposition, the sub-surface cells should be located off-line, and be fully protected by pretreatment cells.

–TRS

References

Egan, T.J. S. Burroughs and T. Attaway. 1995. "Packed Bed Filter." *Proceedings of 4th Biennial Symposium on Stormwater Quality*. Southwest Florida Water Management District. Brookeville, FL. pp. 264-274.

Reed, Sherwood. 1995. *Submerged Vegetated Bed Wetlands: A Technology Assessment.* Office of Water. U.S. EPA. Washington, DC.

Table 1: Average Mass Removal of the Packed Bed Filter System (Egan *et al.*, 1995)

Parameter	Mass removal rate (%)
Total Suspended Solids	81
Total Dissolved Solids	8
Total Organic Carbon	38
Total Kjeldahl Nitrogen	63
Nitrate-Nitrogen	75
Total Nitrogen	63
Orthophosphate	14
Total Phosphorus	82
Cadmium	80
Chromium	38
Copper	21
Lead	73
Zinc	55
Fecal Coliforms	78

Note: 15 simulated storms