CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT

Nitrogen: Public Water Enemy #1

Residential onsite wastewater treatment systems (OWTS) have been identified as a potentially significant source of nitrogen in many regions. Currently over 360,000 homes in Suffolk County are being served by conventional onsite wastewater treatment systems consisting of a septic tank and leaching rings or cesspools, which are designed to rapidly disperse wastewater deep into soils. While these conventional onsite wastewater systems remove suspended solids, they provide minimal nitrogen removal (US EPA 2002). Nitrogen discharged from these systems may contaminate drinking water supplies and can flow into sensitive coastal environments where it may o contribute to the formation of harmful algal blooms, oxygen-deprived waters, the loss of seagrass and wetlands, the depletion of shellfish populations, and fish kills. Given excess nutrient discharge from traditional onsite systems pose extensive threats to groundwater and surface water, there is a strong need to develop affordable innovative and alternative onsite wastewater treatment systems (I/A OWTS) with enhanced nitrogen removal capabilities.

Constructed Wetlands for Water Purification

Constructed wetlands and various modifications to traditional wetland configurations, including recirculating gravel filters, have been identified as a promising alternative wastewater treatment technology. The development of constructed wetlands has shown significant removal of nitrogen and other contaminants as wastewater flowed through the wetland (Mitsch and Gosselink 2007; Vyzmal 2011). Over time, constructed wetlands have developed into a relatively robust, low-energy, low- maintenance and low-cost system that has been used for the treatment of contaminated waters from many sources including industrial waste, agricultural waste, and storm water runoff (Kadlec and Wallace 2009). These artificial systems simulate the functions of natural wetlands to treat water through physical, chemical and biological mechanisms.

Engineered wetlands can be classified based on the hydrology and flow path of the system. Horizontal or vertical subsurface flow wetlands are most widely applicable in the case of domestic wastewater because the media is contained below ground and there is limited exposure of wastewater to the atmosphere. The primary components of constructed wetlands are the substrate, typically sand or gravel to reduce clogging potential, emergent macrophytes, and a diverse microbial community that aids in biotic purification of water. Influent wastewater is distributed to the system in continuous or uniform doses and the various constituents of wastewater are treated as it percolates through the media and comes in contact with plants and the diverse microbial community attached to the media surface. Depending on the design of the wetland, systems typically achieve 30–50% reduction in nitrogen (in addition to significantly reducing TSS, BOD and other contaminants such as metals and organic contaminants

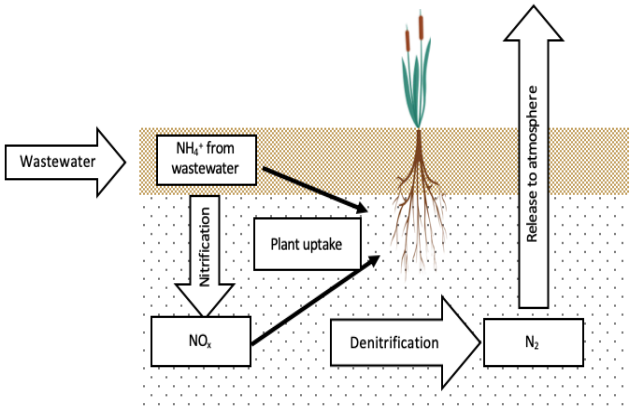

Fig 1. Major conventional nitrogen transformation processes in constructed wetlands.

in wastewater). Figure 1 highlights the dominant nitrogen transformation pathways in constructed wetlands. Traditionally, coupled nitrification-denitrification represent the primary nitrogen removal pathways, although recently novel processes such as anaerobic ammonium oxidation (Anammox) and completely autotrophic nitrite removal (Canon) have been identified (Saeed and Sun 2012; Kumar and Dutta 2019). To address increasingly stringent effluent discharge standards, enhancements to constructed wetlands such as intermittent aeration and recirculation can be implemented to promote higher (>80%) rates of nitrogen removal (Wu et al., 2015; Nivala et al., 2019).

Research on Nitrogen Removal in Constructed Wetlands at the NYS Center for Clean Water Technology (CCWT)

Current research at the NYS CCWT is focused on better understanding the geochemistry and microbiology of nitrogen removal in constructed wetlands. Several constructed wetland configurations are being tested by the Center in order to maximize nitrogen removal and minimize cost these systems. These systems include:

• A seasonally-operated constructed wetland system utilizing partial saturation and recirculation to promote nitrogen removal installed at Sylvester Manor, Shelter Island, NY.

• A series of recirculating gravel filters of different planting densities operated in sequence with a denitrifying media column installed at the Massachusetts Alternative Septic System Test Center (MASSTC) in Barnstable County, MA.

• A series of vegetated, recirculating gravel filters with ornamental and traditional wetland plant species operated with a denitrifying woodchip bed at The Nature Conservancy at Uplands Farm.

Monitoring data from these systems suggest that constructed wetlands can achieve yearly average effluent nitrogen concentrations of substantially less than 19 mg/L, the required nitrogen limit for I/A OWTS in Suffolk County. Additionally, this research has demonstrated that vegetation may also mediate nitrogen removal mechanisms in constructed wetlands. In the near-term, we will continue to monitor and assess treatment and performance of constructed wetlands over extended periods of time. We will also examine whether the performance of seasonally-active systems differs from systems that are in operation year-round and continue research in developing a better understanding of the role of plants in nitrogen removal.

In addition to the systems that are routinely being monitored, the Center will be piloting two innovative constructed wetland configurations at the New York State CCWT Wastewater Research and Innovation Facility (WRIF) in the upcoming months to test the effects of different operational strategies for nitrogen removal performance intensification.

It is the goal of the Center to develop, refine, and commercialize a wastewater treatment technology that is effective, resilient, affordable, and long-lasting, thus meeting our goal of 10:10:30 (i.e., effluent concentrations <10 mg/L, cost <$10,00, and lasting >30 years). Constructed wetlands represent a technology that can achieve these goals. CCWT has prepared and submitted a guidance document to Suffolk County formalizing and detailing the methods for installing wetlands as an I/A OWTS. With approval of this document and a year of performance data from three wetlands-based I/A OWTS that achieve < 19 mg/L nitrogen effluent, wetlands will become provisionally approved for widespread use as an I/A OWTS in Suffolk County.

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