Floating Treatment Wetland Technology: Nitrate Removal in Wastewater Lagoons

This case study illustrates the Floating Island International (FII) patented floating treatment wetland (FTW) technology and its ability to reduce nitrate levels in wastewater. Constructed of post-consumer polymer fibers ("matrix") and vegetated with native plants, FTWs mimic the ability of natural wetlands to clean water by bringing a "concentrated wetland effect" to any water body – in this case, a wastewater lagoon.

Since their initial implementation nearly a decade ago, one of the primary objectives of FII's floating treatment wetlands has been to reduce objectionable nutrient levels. Potential applications include waterways degraded by agricultural runoff, ponds and lakes impacted by waterfowl and/or septic systems, polishing of municipal wastewater and even treatment of raw wastewater.

Table 1 illustrates nitrate removal in three studies equipped with FTWs. The table includes nitrate concentrations, percent removals and removal rates in pounds of nitrate-nitrogen removed per year per cubic foot of FTW material.

TABLE 1. FTW NITRATE REMOVAL

	Nitrate-N Concentration (mg/L)			Percent Removal		Removal Rate (lb/yr/ft^3)	
Study	**Influent**	**FTW**	**Control**	**FTW**	**Control**	**FTW**	**Control**
MBRCT Tank Test	236	0	NA	100%	NA	12.7	NA
MBRCT Test Pond	150	0	78	100%	44%	0.9	0.4
Wiconisco	9.6	2.5	4.1	74%	57%	3.0	2.9

The three systems presented in Table 1 are variations of wastewater lagoons at different scales. The earliest study conducted by FII researchers for a Montana Board of Research and Commercialization Technology (MBRCT) grant was a small-scale FTW (tank test) which did not include a "control" lagoon. The other studies included controls, which were parallel lagoons treating the same influent wastewater but without FTWs.

The Wiconisco FTW is a full-scale system treating an average flow of 16 gallons per minute (gpm). It treats municipal wastewater, with low initial nitrate concentrations but high ammonia levels (approximately 40 mg/L). The influent concentration for Wiconisco in Table 1 does not reflect the nitrate concentrations after nitrification (aerobic conversion of ammonia to nitrate) had occurred. However, the nitrate removal rate shown in Table 1, 3 lb/ft^3/yr, does include removal of the nitrate-nitrogen that had been converted from ammonia, since this nitrogen is no longer present as ammonia or nitrate in the effluent. These data are shown in the FII "Ammonia Removal" case study.

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Denitrification (biological reduction of nitrate to nitrogen gas under anoxic conditions) is the primary mechanism for nitrate removal in these systems. Although the Wiconisco FTW was aerated for ammonia removal, it achieved anoxic conditions (and subsequent nitrate removal) in the presence of dissolved carbon in the wastewater, which acts as a food source for denitrifying bacteria. The Wiconisco FTW and many other FII installations are located in cold-weather climates, which has traditionally limited biological nitrate removal.

Researchers have estimated that approximately 80% of the FTW efficacy is due to bacteria attached to plant roots and the FTW polymer matrix itself, with the other 20% attributed to nutrient uptake by plants. The plants create the platform for biological activity in a biofilm, while also contributing nutrient uptake and aesthetic benefits. This is illustrated in Figure 1.

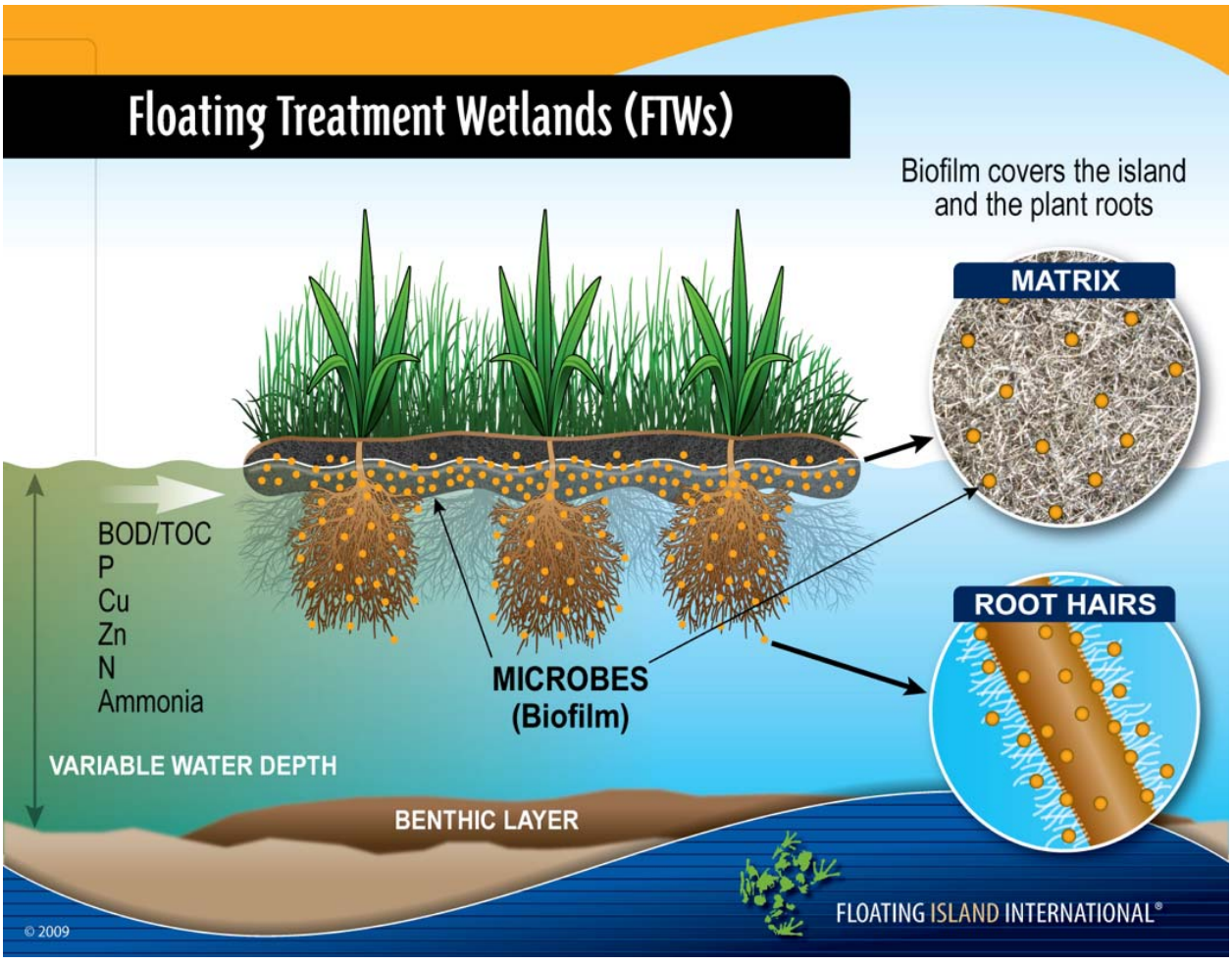

Figure 1. Illustration of FTW biological activity

The Wiconisco system was one of the first full-scale FTWs installed in 2005, and is shown in Figure 2.

Figure 2. Mature FTWs at Wiconisco, 2009

Conclusion:

The need to reduce nutrient levels in wastewater is increasingly critical as rivers, lakes and coastal waters become more nutrient-loaded worldwide. This is the entry point for cutting edge, "green" floating treatment wetland (FTW) technology.

Although traditional wastewater lagoons can reduce BOD and TSS, their ability to remove nitrogen and phosphorus from municipal wastewater is limited. FTW technology enhances these lagoons with the "concentrated wetland effect," facilitating compliance with increasingly stringent wastewater nutrient, BOD and TSS criteria.

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