

Nutrient Removal from Reclaimed Water with Floating Treatment Wetlands

Project Location: Pasco County, Florida USA

An independent study conducted by CH2M Hill demonstrates the ability of BioHaven® floating treatment wetland (FTW) technology to further reduce nutrient levels in reclaimed municipal wastewater, which would assist in meeting total maximum daily load (TMDL) limits. In addition to removing total nitrogen (TN) and total phosphorus (TP), FTWs provided the ancillary benefits of:

- Increasing wildlife habitat;
- Reducing local nuisance insect populations; and
- Increasing pond aesthetics.

Overview

CH2M Hill supervised installation of 20 FTWs in a test pond containing approximately five million gallons of reclaimed water from the Pasco County Master Reuse System (PCMRS). Each FTW measured 8 ft x 10 ft and accommodated 154 plants. The primary objective of this study was to quantify nitrogen removal by the FTWs, in the hopes of demonstrating the benefits of FTWs in TMDL-limited watersheds. Total nitrogen is the parameter currently limiting reclaimed water use within the PCRMS. FTWs were envisioned as a more efficient alternate to treatment wetlands where land area may be constrained.

Location	Pasco County, Florida USA
Parameters Studied	Total nitrogen, total phosphorus, ammonia, nitrate, biochemical oxygen demand (BOD), total suspended solids (TSS), dissolved oxygen (DO), pH, temperature
Environment	Publicly-owned wastewater retention pond
FTW Size	Area of 1,600 ft ² (150 m ²), thickness of 8 inches (20 cm)
Water Source	Secondary effluent from wastewater treatment facilities (WWTFs)
Installation Date	July 2012
Flow Rate	138 gpm (31 m ³ /hr)
Water Body Depth	4 ft (1.2 m)
Water Body Area	4 acres (1.6 hectares)
% Coverage	0.9% of retention pond covered by BioHavens

The PCMRS is a regional reclaimed water transmission and distribution system providing wastewater effluent disposal for Pasco County and the City of New Port Richey. With 15 golf courses and approximately 12,000 residential users connected, the

PCMRS reclaims approximately 20 million gallons per day (mgd) of advanced secondary treated effluent from seven local WWTFs.

The FTWs, supplied by Martin Ecosystems Inc. of Baton Rouge, LA, were planted with emergent wetland vegetation. Water quality was monitored biweekly over the 17-month test period. The study consisted of three phases: 1) a six-month “grow-in period” for plants to become established, 2) an eight-month “performance period” with established plants on FTWs, and 3) a three-month “control period” after removal of the FTWs. The average hydraulic residence time in the pond was about 20 days.

Water Quality Effects

FTWs had a positive effect on TN, TP and pH as shown below:

Parameter	Performance Period			Control Period		
	In	Out	Removal	In	Out	Removal
Total N (mg/L)	6.10	2.04	67%	4.47	3.44	23%
Total P (mg/L)	1.96	0.63	68%	1.37	1.00	27%
pH (s.u.)	NA	9.96	NA	NA	11.25	NA

Removal of TN and TP was substantially higher during the FTW performance period than during the control period. Nutrients were still removed during the control period, probably due to some bacterial activity and solids settling in the test pond. However, bacterial and plant nutrient removal processes were substantially enhanced during the performance period. Net nutrient removal rates attributable to the FTWs can be calculated by subtracting the control removal from the performance removal. Those rates, based on the amount of FTW present in ft³, were 1.7 lb/yr/ft³ for TN and 0.54 lb/yr/ft³ for TP.

Most of the total nitrogen was present as nitrate. It was found that water temperature, which averaged 23°C during the performance period, did not affect nitrate removal over the temperature range examined.

pH increased in the test pond as algal photosynthesis produced a large amount of alkalinity. However, this pH increase was mitigated during the performance period and values (recorded automatically every hour) were much less variable with the FTWs.

No removal of TSS or BOD was seen in the study. TSS increased by over an order of magnitude due to algal growth in both the performance and control periods. The influent BOD was typically less than 5 mg/L.

Removal Mechanisms

It has been noted in previous FTW studies that only 10-20% of the nutrient removal is performed by plants, with the majority of nutrient removal performed by bacteria attached to the FTW matrix and plant roots (biofilm). In the Pasco County study, plant samples were harvested during the performance and control periods to analyze the

nitrogen, phosphorus and carbon contained in the plants. It was estimated that only 0.3% of the nitrogen removed was contained in above-ground plant matter during the performance period, and 0.8% during the control period. The remaining nitrogen removal can be attributed to plant roots, bacterial activity and chemical/physical processes. A mass balance estimated that 57% of the TN removed during the performance period was denitrified to nitrogen gas.

Ancillary Benefits

Four main benefits have been historically attributed to FTWs:

1. Water purification,
2. Habitat improvement,
3. Erosion protection and
4. Enhanced landscapes.

Benefits identified in the Pasco County study were:

- **Wildlife habitat.** Wildlife was observed on several occasions utilizing the FTW habitat. Birds included black-necked stilts, clapper rails, boat-tailed grackles and ducks (which built nests). Turtles were also observed resting on the FTWs.
- **Nuisance insect species control.** The FTW habitat also benefits smaller organisms such as aquatic and terrestrial insects. These invertebrates find refuge and food sources within the dense submerged roots and emergent vegetation. Insects that are dependent on water bodies for habitat, such as dragonflies and damselflies, can help reduce the local populations of nuisance species through natural predation. During the performance period, WWTF staff noted no large hatches of midges, which can be a nuisance to people and even be vectors for the spread of diseases such as West Nile virus, and – contrary to previous years - there were no complaints by neighboring residents.
- **Aesthetics.** Adding FTWs to the WWTF pond increased the overall aesthetics. The variety of grasses, rushes and flower plants on the FTWs provided natural aesthetics to a pond otherwise devoid of vegetation.

Conclusions

- Floating treatment wetlands (FTWs) installed in a test pond removed substantial concentrations of total nitrogen and total phosphorus from reclaimed water. Nutrient removal with FTWs was significantly greater than when the FTWs were removed from the system.
- Plant uptake provided only a small percentage of the total nitrogen removal.
- FTWs provide productive habitat for invertebrates and wildlife. A diverse selection of vegetation and species was sustained on the islands.