

Evaluation of constructed wetlands for treating hydroponic waste solution containing high nitrate from greenhouses in South Korea

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Abstract

To treat the hydroponic waste solution containing high nitrate in constructed wetlands (CWs), the optimum conditions of *Thiobacillus denitrificans* (sulfur oxidizing denitrifying bacteria) were investigated in batch experiments under various conditions (amount of sulfur, the ratios of sulfur to calcite, and temperatures). For treating the hydroponic waste solution using *Thiobacillus denitrificans*, the optimum conditions were 3:1 for the ratio of sulfur to calcite and 30 °C for temperature in the study. To obtain optimum configuration, depth and loading of CWs for treating of hydroponic waste solution (HWS) which was produced in greenhouses, the study was conducted with four kinds of combined systems such as Vertical flow (VF)-Horizontal flow (HF), VF-VF, HF-VF and HF-HF CWs. In four configurations of CWs, the treatment efficiency of pollutants (COD, SS, T-N and T-P) under HWS loading and various HWSs were investigated. The optimum HWS loading was 300 L/m²/d in four configurations of CWs. Depending on the optimum HWS lading, removal rate of COD, SS, T-N and T-P in HF-HF CWs was higher than that in HF-VF CWs under various HWSs (from cucumber, paprika and strawberry cultivation). Optimum configuration of 2-stage hybrid CWs was HF-HF CWs for treating hydroponic waste solution in greenhouses. Therefore, under the optimum conditions, removal rate of COD, SS, T-P, T-N and NO₃-N in HF-HF CWs were 53, 91, 91, 69 and 71%, respectively. Removal rate of nitrate in CWs with sulfur oxidizing denitrifying bacteria was higher than that in CWs without sulfur oxidizing denitrifying bacteria.

Key Words

Constructed wetlands, hydroponic waste solution (HWS), greenhouses, sulfur oxidizing denitrifying Bacteria (*Thiobacillus denitrificans*).

Introduction

Constructed wetlands are low-cost alternatives for treating municipal, industrial and agricultural wastewater. Over the last two decades, several studies have reported the potential use of wetlands for removal of nutrients, including nitrogen (N) and phosphorus (P) from wastewater (Reddy and Smith 1987; Mitsch and Cronk 1992). The objective of the study was to evaluate the constructed wetlands for treating hydroponic waste solution containing high nitrate from greenhouses in South Korea.

Methods

The small-scale hybrid constructed wetlands (located in Gyeongsang National University, South Korea at 35°16'N latitude and 127°56'E longitude) evaluated in the study consisted of 2-stage beds containing filter media (coarse sand, broken stone, and mixed filter media). The 2-stage hybrid CWS was conducted with 4 kinds of combined systems such as Vertical flow (VF)-Horizontal flow (HF), VF-VF, HF-VF and HF-HF CWs. The VF bed was 0.5 m (width) × 0.5 m (length) × 1.0 m (height) for the VF bed (0.25 m³ total volume). The HF bed was 0.7 m (width) × 0.35 m (length) × 1.0 m (height) for the HF bed (0.25 m³ total volume). In the VF bed, a ventilation pipe was installed at the bottom at 0.5 m in order to maintain natural ventilation. The HF bed was divided into four sections to maximize the hydraulic retention time in the bed.

Results

Optimum HWS loading and configuration of 2-stage hybrid CWs was 300 L/m²/d and HF-HF CWs for treating hydroponic waste solution in greenhouses, respectively. Under optimum conditions, removal rates of COD, SS, T-P, T-N and NO₃-N in HF-HF CWs with *Thiobacillus denitrificans* was 53%, 91%, 91%, 69% and 71%, respectively. In control, the removal rates of COD, SS, T-P, T-N and NO₃-N in HF-HF CWs without *Thiobacillus denitrificans* was 55%, 93%, 93%, 51% and 47%, respectively.

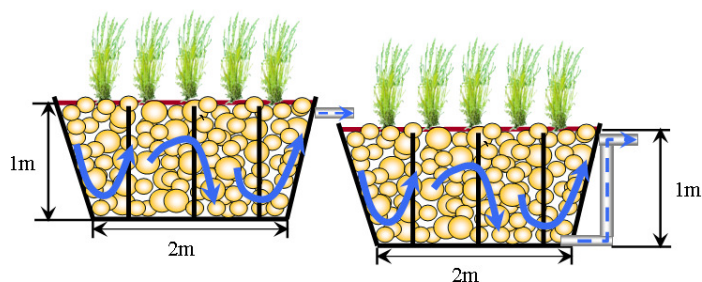


Figure 1. Diagrams of small-scale hydroponic waste solution treatment plant.

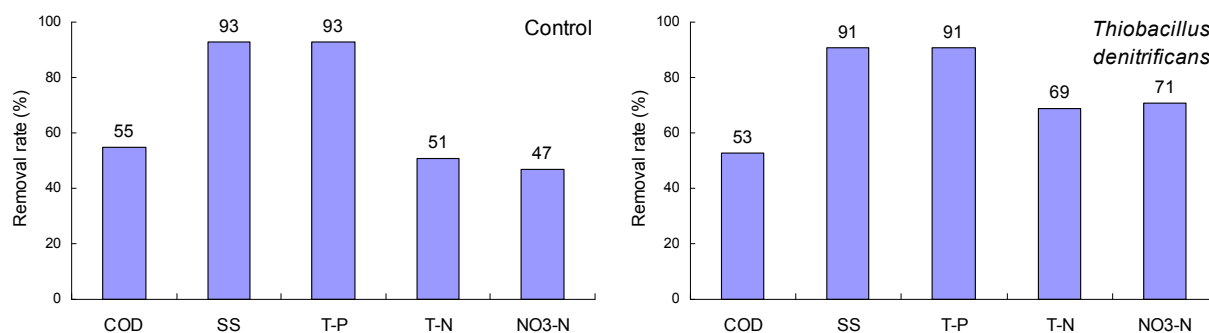


Figure 2. Removal rates of COD, SS, T-N T-P and NO₃-N the effluent under conditions of *Thiobacillus denitrificans* in HF-HF hybrid CWs.

Conclusion

In batch experiment, the optimum conditions were 3:1 for the ratio of sulfur to calcite and 30 °C for temperature in this study for treating the hydroponic waste solution containing high nitrate using *Thiobacillus denitrificans*. The optimum HWS loading was 300 Lm²/d in four configurations of CWs. In addition, optimum configuration of 2-stage hybrid CWs was HF-HF CWs for treating hydroponic waste solution from greenhouses in CWs. Depend on optimum conditions, the removal rates of COD, SS, T-P, T-N and NO₃-N in HF-HF CWs with *Thiobacillus denitrificans* was 53%, 91%, 91%, 69% and 71%, respectively.

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