ECOLOGICAL ENGINEERING 32 (2008) 68–71

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/ecoleng

Organic matter, anion, and metal wastewater treatment in Damyang surface-flow constructed wetlands in Korea

*Noeon Park, Joon Ha Kim, Jaeweon Cho**

Department of Environmental Engineering and Science, Gwangju Institute of Science and Technology (GIST), Oryong-dong 1, Buk-gu, Gwangju 500-712, Republic of Korea

ARTICLE INFO

Article history:
Received 7 April 2007
Received in revised form
25 August 2007
Accepted 3 September 2007

Keywords:
Constructed wetlands
Effluent organic matter
Heavy metals and metalloids
Toxic anions
Denitrification

ABSTRACT

Surface-flow wetlands constructed with *Acorus* and *Typha* plants, connected to a wastewater treatment plant, were investigated with respect to organics (dissolved organic matter), anions (nitrate, sulfate, and phosphate), metals (Cu, Ni, Zn, Fe, and Mn), and metalloids (As). The results of the research indicated: (1) effluent organic matter (EfOM), based on dissolved organic carbon (DOC), was not efficiently removed by the wetlands. However, the hydrophobic, transphilic, and hydrophilic EfOM fractions varied throughout the wetlands, as identified by XAD-8/4 resins. (2) Nitrate, as compared to sulfate and phosphate, was efficiently removed, especially in the *Typha* wetland pond that had long retention time, under anoxic condition. (3) Most of the heavy metals were ineffectively removed via the wetland ponds. However, the iron concentration increased in the *Typha* wetland pond, which was probably due to its reduction under anoxic condition.

1. Introduction

Much research has been performed on constructed wetlands with respect to the control of organics, nutrients, and heavy metals, as well as many other components (Brix and Arias, 2005; Vymazal, 2005; Maine et al., 2006; Song et al., 2006). When constructed wetlands have previously been used for the treatment of wastewater effluents, they have generally exhibited high removal efficiencies for organics (60–99%), in terms of BOD and COD, and intermediate (sometimes low) efficiencies for nutrients, in terms of ammonia, nitrate, total phosphate, etc. (Brix and Arias, 2005; Vymazal, 2005). Kadlec and Knight (1996) and Kolka and Thompson (2006) investigated and summarized many case studies on the use of wetlands for the treatment of various contaminants, including organics, nutrients and heavy metals. They concluded that if constructed wetlands are properly built and effectively operated, they can provide good performance with regard to many different contaminants. It was unclear if certain constructed wetlands were designed especially for the control of heavy metals, but they have been found to exhibit good performance for selected metals (Maine et al., 2005, 2006).

Despite overall-investigative studies (i.e., removal trend by wetlands), research based more on the mechanistic characterizations of the performance of constructed wetlands is relatively rare (subject is research). Thus, further suggested research may include: (i) rigorous characterizations of organic matter (in terms of molecular weight, relative hydrophobicity, etc.) through various wetlands under different conditions, along with total organic mass control, (ii) nutrient control, mostly by biotic activities (e.g., nitrification or denitrification (Fleming-Singer and Horne, 2002)), and (iii) heavy metal control, by either biotic or abiotic activities.

* *Corresponding author*. Tel.: +82 62 970 2443; fax: +82 62 970 2434.
E-mail address: jwcho@gist.ac.kr (J. Cho).
0925-8574/$ – see front matter
doi:10.1016/j.ecoleng.2007.09.003

The objective of this work was to investigate the efficiencies of constructed wetlands connected to wastewater treatment plants, in terms of effluent organic matter, anions, and heavy metals.

2. Methods and materials

Wastewater effluent, treated by secondary and advanced (in terms of nitrification) wastewater plants, and wetland samples were taken from the Damyang wastewater treatment plant and adjacent free surface-flow constructed wetlands, respectively; sampling was performed during summer 2006 and winter 2007. The samples were filtered through 0.45 μm micro-filters, and immediately analyzed for most common constituents, and then stored for further analyses.

Two different wetland ponds were tested; wastewater effluent flowed into the wetlands, which was connected to the Youngsan River. The wetlands included two different ponds, with *Acorus* and *Typha* plants (i.e., wastewater treatment plant → *Acorus* pond → *Typha* pond → wetland effluent). The wetland pond with *Typha* also included two different regions: one conveyed water from the *Acorus* pond to the river, which had a short hydraulic retention time; however, the second had a relatively long hydraulic retention time (i.e., somewhat stagnant pond). From an on-site investigation, the water quality of the final wetlands effluent appeared to be influenced mostly by the wetland with *Acorus*, which in turn was slightly influenced by the stagnant wetland with *Typha*. The hydraulic retention time and flow rate of the entire wetlands were designed to be approximately 6 h and 1800 m^3/day, respectively; the average width, length, and depth of the entire wetland were ca. 30, 120, and 0.13 m, respectively.

The levels of organic matter in the wastewater effluent and wetlands were measured using chemical and UV oxidation methods, employing a total organic carbon (TOC) analyzer (Sievers, Boulder, CO, USA), equipped with an auto sampler.

Table 2 – EfOM structural variations through wetlands

Sampling site	Hydrophobic (%)	Transphilic (%)	Hydrophilic (%)
Summer, 2006			
Effluent	31.0	39.3	29.7
Acorus pond	34.8	34.4	30.8
Typha pond	33.6	33.9	32.5
Wetland effluent	29.1	35.0	35.9
Winter, 2007 (January–March)			
Effluent	31.2 (±3.8)	29.7 (±5.0)	39.1 (±1.2)
Acorus pond	37.8 (±10.6)	33.2 (±4.5)	29.0 (±15.1)
Typha pond	38.1 (±15.6)	29.3 (±6.4)	32.6 (±22.0)
Wetland effluent	42.7 (±5.7)	35.3 (±1.4)	22.0 (±7.1)

The UV absorbance was measured at 254 nm, using a UV–vis spectrophotometer (UV-1601, Shimadzu, Japan).

The relative hydrophobicities and hydrophilicities of the samples were determined using XAD-8 and XAD-4 resins; through this fractionation method, the original organics were fractionated into hydrophobic (XAD-8 adsorbable), transphilic (XAD-4 adsorbable, intermediate fraction) and hydrophilic (unadsorbable onto both XAD-8/4 resins) fractions (Kwon et al., 2005).

The metals and metalloids concentrations were measured using ICP–MS (Agilent, 7500ce, USA), with an octopole reaction system, and ultra pure hydrogen and helium gases. All the samples were acidified with 70% nitric acid to a final nitric acid concentration of 2%. To construct standard calibration curves, 10 μL/mL multi-element standard solutions (Agilent, std-2A and std-4) were used. For measurement verification, two different methods were used; internal and standard samples of known concentrations were measured along with the actual samples, using standard reference materials (SRM 1640, NIST) as well as those used in the calibrations, respectively. Each sample was measured in triplicate and then averaged.

A statistical *t*-test (Microsoft® Office Excel 2003) was applied to find the significances of the treatment efficiencies

Table 1 – Water qualities measurement for wastewater effluent and samples in wetlands

Sampling site	DOC (mg/L)	UV at 254 nm	pH	NO_3^- (mg/L)	SO_4^{2-} (mg/L)	PO_4^{3-} (mg/L)
Summer, 2006 (June–September)						
Effluent	7.4 (±1.4)	0.2094	7.3	58.2 (±30.1)	30.6 (±5.1)	4.6 (±0.5)
Acorus pond	7.2 (±2.4)	0.1696	7.2	45.6 (±21.9)	27.5 (±1.8)	4.2 (±1.0)
Typha pond	8.5 (±0.6)	0.2390	7.4	4.8 (±4.4)	15.6 (±9.3)	2.1 (±1.3)
Wetland effluent	7.1 (±2.1)	0.1625	7.4	34.9 (±17.9)	26.9 (±2.1)	4.1 (±0.6)
Winter, 2007 (January–March)						
Effluent	8.1 (±0.1)	–	7.1	66.1 (±6.5)	43.6 (±2.0)	<1.0
Acorus pond	7.4 (±0.6)	–	7.2	60.5 (±3.6)	41.8 (±3.7)	<1.0
Typha pond	12.6 (±5.2)	–	7.0	32.8	25.5 (±11.3)	<1.0
Wetland effluent	11.1 (±4.1)	–	7.6	54.5	31.6 (±18.9)	<1.0

Compared samples (from/to)	DOC	NO_3^-	SO_4^{2-}	PO_4^{3-}
p-Values* from *t*-tests				
Effluent/*Acorus* pond	0.286	0.021	0.093	0.176
Acorus/*Typha* ponds	0.039	0.002	0.007	0.002
Effluent/wetland effluent	0.269	0.016	0.157	0.460

* *p*-Values less than 0.05 imply significant difference in corresponding parameter values between the two samples.