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Comparison of microfauna communities in full scale subsurface flow constructed wetlands used as secondary and tertiary treatment

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ABSTRACT

In order to evaluate the microfauna composition and distribution in two horizontal subsurface flow constructed wetlands used as secondary and tertiary treatment a full-scale wastewater treatment plant was monitored during five months. Results indicate that total microfauna abundance in the wetland treating primary influents is around five times higher than that found in the wetland treating secondary influents. Ciliated protozoa and microflagellates are the most important microfauna groups in both wetlands; microflagellates in terms of abundance and ciliates in terms of biomass. The most abundant ciliate species in the wetland treating primary influents are polysaprobic organisms as *Dexiostoma campylum*, *Trimyema compressum*, and to a lesser extend *Metopus* spp. On the other hand, the most important ciliate species found in the wetland treating secondary influents are mainly aerobic ciliates as *Vorticella comvallaria-complex*, *Aspidisca cicada*, *Litonotus lamella* and some ciliates belonging to the group of the scuticociliates and Hypotrichidae. The sort of the organic matter treated (particulated or dissolved) is at least as important as the amount of it in order to explain microfauna dynamics in constructed wetlands.

1. Introduction

Horizontal subsurface flow constructed wetlands (SSF CWs) are low-cost wastewater treatment systems when compared to conventional systems due to both low energy and manpower required. The application of SSF CWs is increasing nowadays as a suitable alternative for the sanitation of small human agglomerations (Vymazal, 2002; Rousseau et al., 2004a, b) and has been proved to be a technology that can successfully remove a broad range of contaminants commonly found in municipal wastewaters (Vymazal, 1996; Huett et al., 2005; García et al., 2005; Huertas et al., 2006). Despite the rising use of SSF CWs all over the world, the scientific and technical information on this technology is still scarce when compared to conventional wastewater treatment systems. This scarce scientific knowledge on constructed wetlands is specially poor in the topic of microfauna composition, distribution and ecology. In this sense, although microfauna has been reported to be very useful for system optimization and process monitoring in conventional wastewater treatment systems (Curds, 1963; Martín-Cereceda et al., 2002; Puigagut et al., 2005), there is a great lack of scientific information on the use of microfauna in SSF CWs as a bioindicator tool of plant performance and operational

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conditions. Besides the limited information available on this topic, which is mostly focused on the bacterivorous activity of ciliates (Decamp et al., 1999), some recent pilot scale experiments have proven that microfauna is a promising tool for assessing the sort and the amount of organic matter entering to SSF CWs (Puigagut et al., 2007). Thus, the need for scientific knowledge in full-scale systems for the use of microfauna as process monitoring parameter is required in order to increase the number of available tools for both SSF CWs improvement and management.

The objective of this study was to evaluate microfauna composition and distribution in a full-scale plant with a secondary and tertiary SSF CWs.

2. Materials and Methods

In order to evaluate microfauna composition and distribution in SSF CWs used as secondary and tertiary treatment a wastewater treatment plant was monitored from November 2005 to March 2006. The wastewater treatment plant studied is located in Verdú, a small village near Lleida (Catalunya, Spain), and treats municipal wastewater since the start of operation in 2002. The treated flow is in average 177 m^3/day and the plant was designed for 2000 persons equivalent. The configuration of the plant is: screening, three septic tanks in parallel, four horizontal SSF CWs in parallel of 976.5 m^2 each one (that presented signs of clogging in the inlet zone due to the presence of stagnant water), two aerobic ponds in parallel of 2000 m^2 each and two polishing horizontal SSF CWs in parallel with 518 m^2 each one (that did not present any sign of clogging). All the SSF CWs were planted with *Phragmites australis* and have a length-to-width ratio of 1:1.1 and 1:2 to the first and the polishing SSF CWs, respectively. The wetlands were filled with the same coarse granitic gravel ($D_{60} = 9$ mm, $C_u = 1.8$) and have an average wetted depth of 0.5 m and an initial porosity of 40%. Additional information on these facilities can be found in Caselles-Osorio et al. (2007). One of the first four SSF CWs (operating as a secondary treatment, ST) and one of the polishing SSF CWs (operating as tertiary treatment, TT) were studied for lighting on the relationship between the sort of wastewater treated (primary and secondary effluents) and microfauna composition and distribution. Note that in fact the TT SSF CW receives pond effluent.

Physical–chemical parameters as the total COD, colloidal COD (filtered at 1.2 μm), and soluble COD (filtered at 0.2 μm) were measured at the influent of the wastewater treatment plant, effluent of the septic tank, effluent of the ST SSF CWs, effluent of the pond and finally, at the effluent of TT SSF CWs (which in fact is the final effluent) according to APHA-AWWA-WPCF (2001). These parameters were measured from grab samples that were obtained from three sampling campaigns carried out during the period of study. Due to the fact that COD filtered at 1.2 μm and that filtered at 0.2 μm were almost the same, only the fraction below 0.2 μm (as soluble) and the whole particulate fraction (above 0.2 μm) will be considered in the discussion of the results. The company in charge of operation and management of the treatment plant (Aigües de Catalunya SA) provided historical records on total COD. The main physico-chemical and operational parameters of the evaluated SSF CWs are summarized in Table 1. Additional information on the performance of these wetlands can be found in Caselles-Osorio et al. (2007).

In order to analyse microfauna composition and distribution three sections along each of the two SSF CWs were considered. The first two sections were placed within the first third along the length of the wetland (at 2 and 4 m to the inlet point, respectively), whereas the third section was placed within the last third of the wetland (at 2 m of the outlet). In case of the ST SSF CW the two first sections coincided with the zone where stagnant water was observed. At each section three equally distributed sampling points were considered along the width, so the total sampling points for microfauna examination at each SSF CWs analysed were nine (three sampling points per section). Each sampling point for microfauna examination consisted of a plastic perforated tube of 20 cm diameter and 50 cm long inserted within the gravel of the wetland (to the bottom). Furthermore, five sampler devices were placed within the perforated tubes.

Table 1 – Wastewater characteristics (averages ± SD)

	Raw wastewater	ST SSF CW		TT SSF CW	
		Influent	Effluent	Influent	Effluent
Total COD (mg/L)	285.6 ± 207	150.3 ± 105.6	40.6 ± 28.5	32.9 ± 23.1	32.6 ± 23
Particulate COD (mg/L)	240.1 ± 174	125.6 ± 88.2	18.2 ± 12.6	10.9 ± 7.7	10.9 ± 7.7
Soluble COD (mg/L)	45.5 ± 32.9	24.7 ± 17.4	22.4 ± 17.4	21.9 ± 15.4	21.7 ± 15.4
BOD_5 (mg/L)	139.8 ± 124.9	—	—	—	9.4 ± 8.3
Total organic load (g COD/m^2 d)	—	6.8 ± 4.8	—	5.6 ± 3.9	—
Particulate organic load (g COD/m^2 d)	—	5.7 ± 4	—	1.9 ± 1.3	—

Total and particulate organic loads were calculated from the historical COD data provided by the company in charge of the operation of the treatment plant, and considering the removal rates and COD ratios between the different fractions (total, particulate and dissolved) observed in the present study.