

PERFORMANCE OF TWO HORIZONTAL FLOW CONSTRUCTED WETLANDS WITH DIFFERENT VEGETATION IN TREATING DOMESTIC WASTE WATER

M. Borin¹, M.A. Gandini², M.C. Lavagnolo³ and R. Cossu⁴

¹Department of Environmental Agronomy and Crop Production, Univ. of Padova, Italy (maurizio.borin@unipd.it)

^{2,3,4} Department IMAGE, Univ. of Padova, Italy (raffaello.cossu@unipd.it)

Abstract

Grey and yellow water from an experimental source separation toilet are treated in two subsurface horizontal flow beds operating in parallel, one vegetated with *Phragmites australis* only, the other with a community of ten different species having ornamental and aesthetic value. After one year of operation of the system, the water discharged by the ornamental unit presents almost the same quality than the conventional phragmites unit. In both cases the water produced meets the quality limits imposed by the Italian water regulation.

Introduction

The increasing diffusion of natural water treatment systems in rural and small urban communities and isolated housings has stimulated the attention on the use of plants which offer an ancillary aesthetic function in addition to their typical role in wetland treatments. The most commonly-used plants, both in Italy and elsewhere in the world (Kadlec and Wallace, 1996), are *Phragmites australis* Cav. Trin and *Typha latifolia* L., because of their capability in treatment processes and easy of management. Nevertheless these species offer no or insignificant ornamental properties. Very few applications using ornamental plants have been realized and monitored. To widen the possibilities of choice, an aesthetic approach to natural water treatment systems has been developed in the Aquanova project (Cossu *et al.*, 2001; Borin and Tocchetto, 2006), carried out at the Department IMAGE, University of Padova, Italy, where the performance of two horizontal flow constructed wetlands, one vegetated with *Ph. australis* only (CWph), the other (CWor) with a community of ten different ornamental species has been monitored in treating domestic wastewater.

Methods

Two subsurface horizontal flow (SsHF) beds, working in parallel and receiving grey water mixed with yellow, were constructed and planted in October 2002. The beds are rectangular in shape, with a surface area of 4.3 m², bottom slope of 1.5% and average depth of 0.6 m. They are filled with gravel and sand, with 25% porosity.

In October 2002, the ornamental species and common reed were planted in the beds. The following species were chosen: *Acorus calamus* (pale yellow flower), *Alisma plantago aquatica* (white/pink flower), *Canna indica* (red and yellow flower), *Iris psudacorus* (yellow flower), *Lysimachia nummularia* (yellow flower), *Lythrum salicaria* (purple flower), *Mentha aquatica* (purple flower), *Pontederia cordata* (purple flower), *Preslia cervina* (purple flower), *Thalia dealbata* (purple flower), *Typha latifolia* (green flower). *Ph. australis* has a pale green in a panicle inflorescence.

Both receive the same daily water and pollutant loads. Inflow rate is 90 L d⁻¹, with a nominal retention time of 7 days.

Greywater loading started up on November 4th 2002 and a monitoring program was implemented with weekly analysis of the inlet and outlet flow samples regarding: organic matter (COD, BOD₅, TS, VS), nutrients (TKN, NH₃-N, NO₂-N, NO₃-N, TP), metals (Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn), alkalinity, pH, anionic surfactants (MBAS), chloride and sulphide. Coupled with the chemical monitoring, daily measures of temperature, precipitation, evapotranspiration, inflow, outflow, dissolved oxygen and the status of plants have been recorded for the whole period of investigation.

Three different feeding phases were then conducted as reported in Table 1.

Table 1. Feeding phases

Phase	Data	Inflow Load
1	04/11/03-20/03/03	Low-Load Greywater
2	21/03/03-20/05/03	Low-Load Greywater+0.25% Yellow Water
3	21/05/03-01/12/03	Low-Load Greywater+1.00% Yellow Water

Results and discussion

Table 3 reports the average, maximum and minimum values of the inflow and outflow concentrations taking into account the second and the third feeding phases, since the first phase the load was too small appreciate the depurative efficiency. The abatement of the main parameters was quite similar between the two CW planted with different types of vegetation.

Table 2. Inflow and outflow descriptive statistics of all the data collected in phases 2 and 3

Parameter (mg/L)	Inflow			Outflow					
	Average	Min	Max	Cw ornamental			Cw phragmites		
	Average	Min	Max	Average	Min	Max	Average	Min	Max
TKN	16,9	3,3	35,4	7,71	3,36	16,50	6,89	3,36	12,6
NH ₃ -N	11,9	0,1	28,6	4,25	0,53	10,41	3,84	0,19	7,70
NO ₂ -N	0,1	0,0	1,3	0,01	0,00	0,03	0,01	0,00	0,02
NO ₃ -N	4,0	0,0	14,0	0,16	0,03	0,74	0,20	0,00	0,96
TP	0,8	0,1	3,0	0,28	0,04	0,98	0,26	0,04	0,65
BOD ₅	42,4	29,2	105	25,8	2,0	70,0	26,6	6,00	48,0
COD	151	124	191	51,2	24,0	87,1	50,5	9,68	96,8
MBAS	27,6	26,1	31,2	1,19	0,01	9,06	0,80	0,01	4,80

ALK	322	213	413	374	295	505	371	280	480
pH	7,17	6,75	8,37	6,9	6,5	7,4	6,84	6,53	7,40
TS	393	199	570	373	200	640	400	225	650
TVS	188	105	331	177	15	315	160	25,0	250
Cl	38,1	21,6	70,9	48,8	31,2	89,7	45,7	31,6	67,40
SO ₄	28,8	7,77	60,4	13,3	3,7	124	9,56	1,16	33,20
Cd	0,0002	0,0000	0,0021	0,001	0,000	0,016	0,0005	0,0000	0,0070
Cr	0,1086	0,0000	0,4637	0,094	0,000	0,392	0,1747	0,0000	1,2600
Cu	0,0740	0,0010	0,3470	0,038	0,000	0,263	0,0559	0,0000	0,2770
Fe	0,0107	0,0002	0,0624	0,212	0,000	0,775	0,2506	0,0000	1,2500
Mn	0,0042	0,0000	0,0328	0,108	0,023	0,227	0,1301	0,0210	0,2310
Ni	0,0071	0,0000	0,0333	0,005	0,000	0,023	0,0037	0,0000	0,0230
Pb	0,0013	0,0000	0,0171	0,000	0,000	0,000	0,0000	0,0000	0,0000
Zi	0,1960	0,0122	0,5326	0,000	0,000	0,000	0,0029	0,0000	0,0440

Similarly, only small differences were obtained considering the removal efficiency calculated in terms of mass balance of the main parameters (figure 1). In particular the CW vegetated with *Ph. australis* had a slight better removal of COD and TKN during autumn and winter.

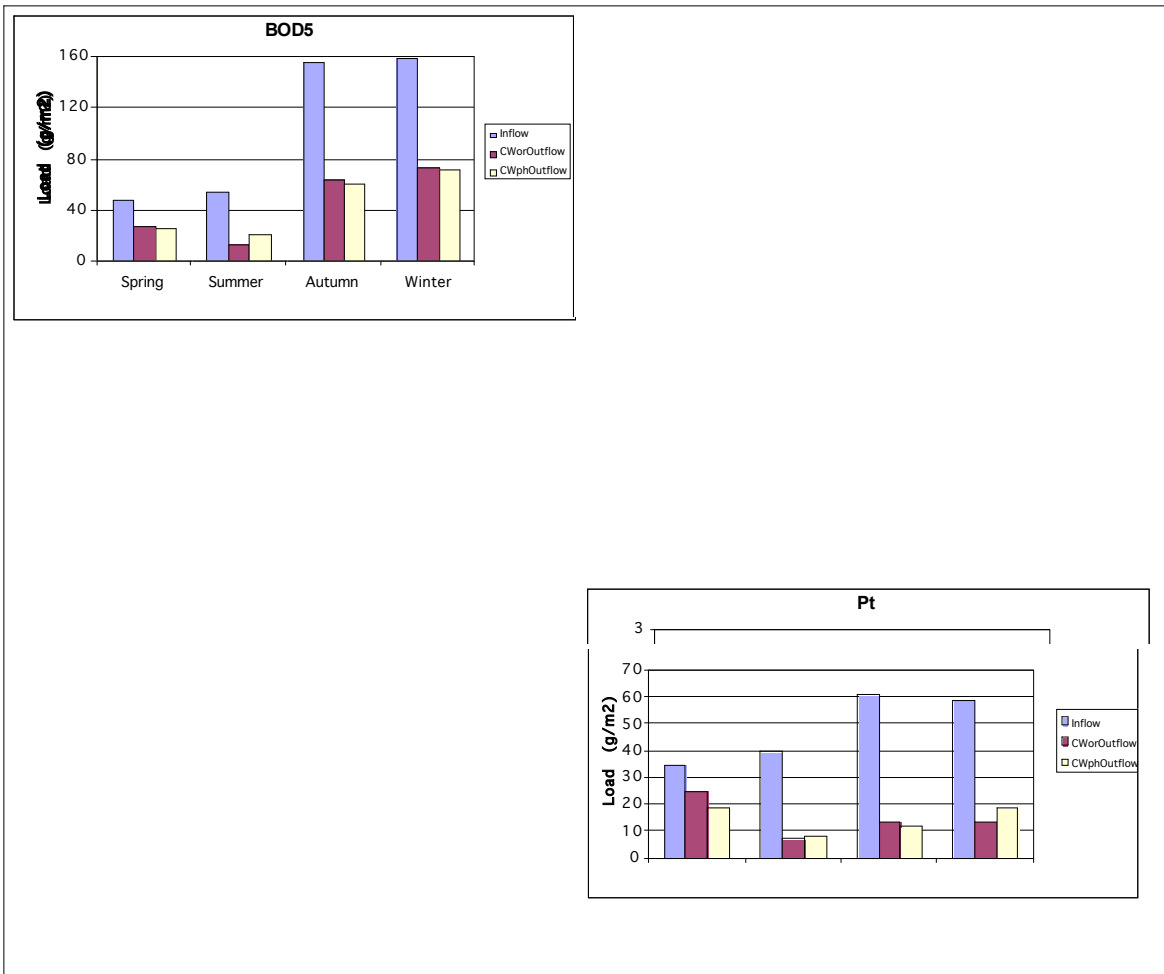


Figure 1. Mass balance of the two SsHF for the main pollutants in the different seasons

Conclusions

After one year of operation, in which the plant was fed with low pollutant loads, the quality of the water produced by the CW vegetated with ornamental species is almost the same as the quality produced by the *Ph. australis* CW, with similar mass removal. In both cases the water quality produced met the discharge quality limits imposed by the Italian regulation. The results encourage to adopt the aesthetic approach for CW in urban and domestic context.

References

Borin M. and Tocchetto D. (2006). Ornamental plants in sub-surface horizontal flow treatment system. Proc. 10th Int. Conf. On Wetland Systems for Water Pollution Control, Lisbon, Portugal, 1085-1092.

Cossu R., Borin M., Lavagnolo M.C., Bigon E. and Spinato P. (2001). A new approach to integrated wastewater and solid waste management. In: Christiansen T.H., Cossu R. e Stegmann R. (eds.):

Sardinia 2001, Eighth Intern. Waste management and landfill symposium, CISA, Envir. San. Engeneer. Centre, 237-246.

Kadlec, R. and Wallace, S. (2009): Treatment Wetlands. 2nd edition, CRC press, Boca Raton, FL, USA.