Proceedings of the 8th Hungarian Congress on Plant Physiology and the 6th Hungarian Conference on Photosynthesis, 2005

Volume 49(1-2):81-83, 2005
Acta Biologica Szegediensis
http://www.sci.u-szeged.hu/ABS

The use of the reed (*Phragmites australis*) in wastewater treatment on constructed wetlands

Csilla Todorovics*, Tamás M Garay, Zoltán Bratek

Department of Plant Physiology and Molecular Plant Biology, Eötvös Loránd University, Budapest, Hungary

ABSTRACT The constructed wetland is a near-natural wastewater treatment technique, where reed (*Phragmites australis*) is an important component. The high rate of small residential settlements (less than 2000 population equivalent (PE) in Hungary suggests the consideration of cost-effective, locally operating wastewater treating methods. The present casework compares the conventional activated sludge treatment with the near-natural root-zone technology by means of the pollutant removal capacity of currently operating waste treatment plants. Examination of the water quality data shows that reed bed systems have a stable removal efficacy of organics of a similar rate to the conventional technologies, while in view of nutrients they have higher retention ability, so are beneficial against eutrophication.
Acta Biol Szeged 49(1-2):81-83 (2005)

KEY WORDS

wastewater treatment
constructed wetland
reed bed
water quality
pollutant removal

Collecting and treating domestic wastewater is one of the current environmental issues in Hungary. While about 98% of the settlements are provided with fresh water only 36,6% have a sewage system. This ratio is worse amongst small residential settlements (OSAP 1062. 2002). The amount of wastewater produced by small settlements is in many cases not enough for the cost-effective operation of a conventional treatment plant. Meanwhile the centralized wastewater treatment of an area has many drawbacks (Lengyel and Kovács 2003). Therefore, the usage of constructed wetlands could provide a viable alternative.

Constructed wetlands are complex biological systems that mimic natural self cleansing processes (Begg et al. 2000). The basic contaminants of such systems are vascular plants (most commonly *Phragmites australis*) alongside the saturated substrate and microorganisms (Kowalik et al. 1995).

Organics and nutrient removal is mostly performed by attached microbiota (Tanner 2000; Wetzel 2000), but research carried out with planted and unplanted beds side-by-side on the same substrate shows that plants have a significant influence on the nutrient removal (Drizo et al. 1996; Tanner 2000).

Reed contribute to wastewater cleaning processes in many different ways: increasing the permeability and porosity of the substrate (Gampel 2003); creating oxygenated microsites within reducing conditions by releasing oxygen from the roots (Ivándi et al. 1998; Tanner 2000). Through the frequently alternating oxygenated and oxygen-poor microsites even resistant chemicals are affected (Gampel 2003). The withered parts insulate the root-zone during the cold period, so in temperate climates the pollutant removal capacity is affected only slightly by the seasons (Vymazal 2000).

The benefits of constructed wetlands are: 1. low cost of building and maintaining (Ivándi et al. 1998); 2. large tolerance of variable quality and quantity of waste loads and 3. fitting harmoniously into the landscape and providing habitat for wildlife (Reed et al. 1995; Gampel 2003).

The present study compares reed bed systems with conventional sludge treatment plants – from small settlements in West-Hungary operating in similar range of waste-load – by the means of water quality data given by the plant management.

Materials and Methods

Four wastewater treatment plants were visited. In Felsőcsatár and Egyházasrádóc the activated sludge technology is used, while in Kám and Kacorlak reed beds have been built. The incoming wastewater and the outflow of treated water were analysed in periods of 1-2 months by accredited laboratories, using the valid standards. This water quality data covers an average period of two years. Average removal efficacy and specific pollutant load were calculated with the following formulas.

Removal efficacy: $100 \times (c_{in} - c_{out}) / c_{in}$ [%]

Where: c_{in} = concentration of given component in inflow [g/m^3]

c_{out} = concentration of given component in outflow [g/m^3]

Specific pollutant load: $(c_{in} \times V_{av}) / N_{theo}$ [g/m^3 per capita]

Where: V_{av} = average volume of incoming wastewater

N_{theo} = theoretic number of residents (V_{av} / PE; where PE = 150 l per capita)

The analysed parameters are the following: BOD (biochemical oxygen demand), COD (chemical oxygen demand), TSS (total suspended solids), nitrate, ammonia, phosphorus.

*Corresponding author. E-mail: labradorit@gmail.com

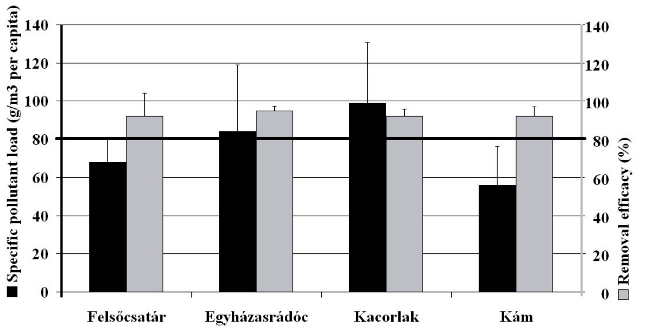

Figure1. Removal efficacy and specific load of biodegradable organics, measured by biochemical oxygen demand ($BOD_5 - O_2$); the bold line shows the regulatory minimal reduction percentage.

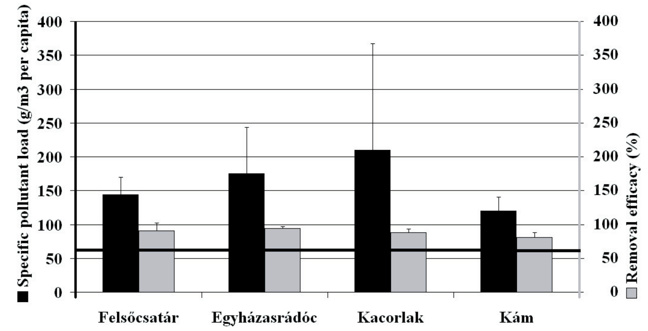

Figure 2. Removal efficacy and specific load of organics, measured by chemical oxygen demand ($COD_{Cr} - O_2$); the bold line shows the regulatory minimal reduction percentage.

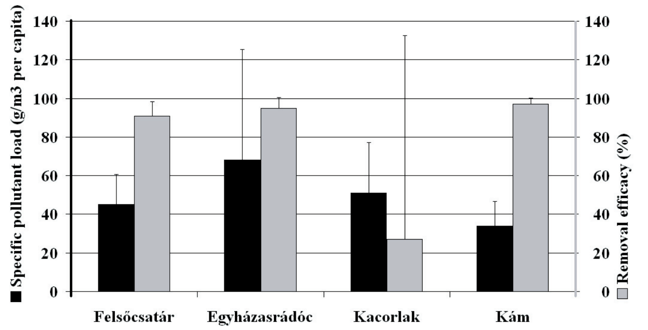

Figure 3. Removal of total suspended solids and the treatment plants' specific load.

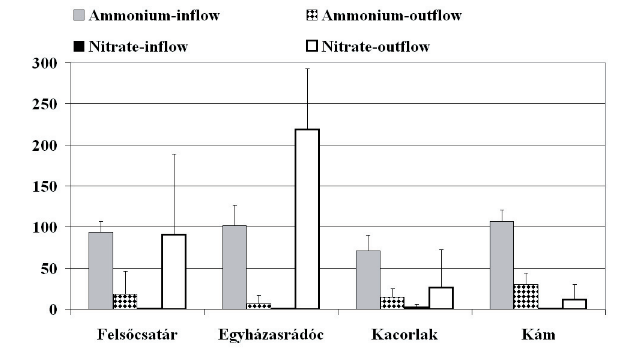

Figure 4. Quantity changes of nitrogen-forms through the treating processes in certain plants.

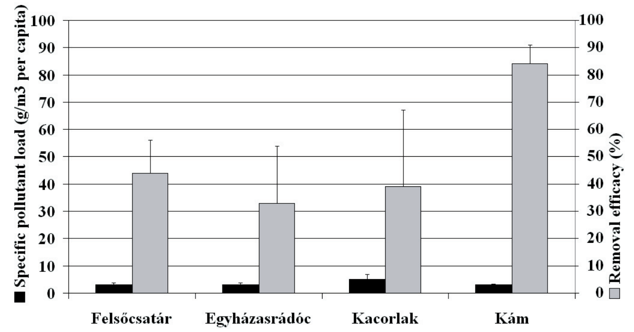

Figure 5. Removal of phosphorus and the treatment plants' specific load.

Results and Discussion

The results of calculations are shown in Figures 1-5.

The wastewater received by all four treatment plants is less in volume and more concentrated than planned, which correlates with the national trends (Lengyel and Kovács 2003). The examined plants operating with the conventional sludge technology receive about 10 times more water than the reed bed systems ($V_{av} \approx 100 m^3/d$ vs. $10\text{-}20 m^3/d$). Despite the grossly fluctuating organic load both technologies have a high and stable reduction capacity, which meets the regulatory standards that came into force recently (9/2002 (III. 22.) KÖM-KÖVIM). It is worth mentioning the specific organic load is the highest in Kacorlak, while the reduction rates are the same as the rest of the treatment plants (Figs. 1,2). Constructed wetlands are mainly designed for organics and suspended solids removal, with appropriate construction these targets can be fulfilled (Vymazal 2000). There can be difficulties in post-treatment as shown in Figure 3 with the suspended solids-removal efficacy of Kacorlak (low reduction, high deviation). Meanwhile the reed beds of Kám (same design) give the best performance with the least deviation.

Figure 4 shows in activated sludge treatment the incoming and the produced (by decomposition processes) ammonia/ammonium is mostly transformed to less harmful nitrate which is discharged to receiving water bodies. In reed beds the nutrient uptake is on a larger-scale and denitrification can be performed also in oxygen-poor microsites; these processes add up to a better retention efficiency. Retention of phosphate mainly depends on the substrate features, high reduction rates could be achieved just by modifying the substrate, while the activated sludge technology would require constant use of chemicals.

Reed beds can perform pollutant reduction on a similar rate to the reduction by the conventional methods. Because of the advantages of reed beds in comparison with the conventional methods (low costs and energy requirements, easy operation, fit to the landscape, etc.) they could be recommended especially for small settlements in Hungary.

References

Begg JS, Lavigne RL, Veneman PLM (2000) *Phragmites* reed beds: Constructed wetlands for municipal wastewater treatment – European perspective. in 7th Int. Conf. on Wetland Systems for Water Pollution Control; University of Florida, pp. 1035-1041.

Drizo A, Frost CA, Smith K A, Grace J (1996) Phosphate and ammonium removal by constructed wetlands with horizontal subsurface flow, using shale as a substrate. In 5th Int. Conf. on Wetland Systems for Water Pollution Control, Vienna, I/10-1 - 8.

Gampel T (2003) Kistelepülések szennyvíztisztítása vízinövényes talajszűrővel. Vízellátás, csatornázás VI. Évf., pp. 70-72.

Kowalik P, Mierzejevski M, Obarska-Pempkoviak H, Tolczyłowska I (1995) Constructed Wetlands for Wastewater Treatment from Small Communities. Wydawnictwo Politechnic Gdańskiej, Gdańs.

Lengyel ZL, Kovács M (2003) Kistelepülések szennyvízkezelése – Helyben vagy távolabb? Vízellátás, csatornázás VI. évf., pp. 73-76.

Ivándi L, Major B, Szilágyi F (1998) Az eleveniszapos és a gyökérmezős szennyvíztisztítás összehasonlítása. XVI MHT Vándorgyűlés 1998. júl. 8-9. I. kötet: 414-428.

OSAP (Országos Statisztikai Alapprogram, adattár; 2002) 1062. ny. sz. Jelentés a települések víz- és csatorna-ellátottságáról.

Reed SC, Crites RW, Middlebrooks EJ (1995) Natural Systems for Waste Management and Treatment második kiadás, McGraw-Hill, Inc. USA.

Tanner CC (2000) Plants as ecosystem engineers in subsurface-flow treatment wetlands. In 7th Int. Conf. on Wetland Systems for Water Pollution Control; University of Florida, pp. 13-22.

Vymazal J (2000) Constructed wetlands for wastewater treatment in the Czech Republic. In 7th Int. Conf. on Wetland Systems for Water Pollution Control; University of Florida, pp. 955-961.

Wetzel GR (2000) Fundamental processes within natural and constructed wetland ecosystems: short-term vs. long-term objectives. In 7th Int. Conf. on Wetland Systems for Water Pollution Control; University of Florida, pp. 3-11.