# FEASIBILITY OF USING ORNAMENTAL PLANTS IN SUBSURFACE FLOW WETLANDS FOR DOMESTIC WASTEWATER TREATMENT

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**Abstract**—Constructed wetlands are possible low-cost solutions for treating domestic and industrial wastewater in developing countries such as Mexico. However, treatment of wastewater is not a priority in most developing countries unless communities can derive economic benefit from the water resources that are created by the treatment process. As part of our studies directed at improving the quality of water in the Rio Texcoco in central Mexico, we are determining the feasibility of using ornamental flowers for treatment of domestic wastewater. In a laboratory-scale study, we determined that subsurface flow wetlands planted with calla lilies could reduce levels of ammonia and nitrate in simulated domestic sewage. Results are presented on the optimal conditions for treatment of domestic wastewater in these systems. Floriculture activities in constructed wetlands could provide the economic benefits necessary to encourage communities in developing countries to maintain wastewater treatment systems.

## INTRODUCTION

Constructed wetlands are a feasible solution to treat domestic wastewater in small rural communities. These systems are especially valuable for onsite wastewater treatment in developing countries because they are low tech, and the costs of construction and operation are low (Denny 1997).

The gains in vegetative biomass in constructed wetlands can provide economic returns to communities when harvested. These can be realized through biogas production, animal feed, fiber for papermaking, and compost (Lakshman 1987). There have been no reports of the use of ornamental plants, such as commercial flowers, in constructed treatment wetlands even though these plants can be harvested and sold.

Most of the research on constructed wetlands has been conducted in northern countries. Therefore, the plants most studied for treatment purposes are cattail (*Typha* spp.), bulrush (*Scirpus lacustris*), and reeds (*Phragmatis australis*) as these plants are native to northern countries (Denny 1997). It is known that ornamental plants like canna lily (*Canna flaccida)*, calla lily (*Zantedeschia aethiopica*), elephant ear (*Colocasia esculenta*), ginger lily (*Hedychium coronarium*), and yellow iris (*Iris pseudacorus*) can be used in rock/plant filters to treat septic tank effluents (Wolverton 1990). However, there is not enough information about the efficacy of these “warm weather” ornamental plants for use in treatment wetlands. Because most developing countries are located in tropical and subtropical areas, the use of ornamental plants for treatment in wetlands should be explored. Floriculture opportunities would also provide economic benefits to the communities in addition to the benefit of the wastewater treatment.

This study is focused on the use of calla lily in subsurface flow wetlands to treat domestic wastewater.

## OBJECTIVES

The objectives of this study are to set up a lab-scale subsurface flow wetland to study the feasibility of using the calla lily to treat simulated wastewater and to assess the efficacy of the system in removing nitrogen from the wastewater.

## METHODS

A lab-scale subsurface flow wetland was installed in a greenhouse at Trent University. The system consists of six cells of 38 cm by 240 cm by 30 cm (width by length by depth) filled with crushed rock of 3 to 5 cm in diameter. Two cells were unplanted and four were planted with calla lilies. The cells were provided with the same simulated domestic wastewater, stored in an elevated tank, at the same flow. The output water was collected and pumped back into the tank. Each cell was planted with 16 plants at a distance of 15 cm between them.

The plants were 8 cm tall when planted. The system was maintained at a temperature range of 14 to 20 $^{o}$C and 16 hours of light per day. After plantation, nutrients were added to the water in the same composition as is used for hydroponics to allow the plants to root and grow. After 120 days, once the plants were well established, lawn fertilizer and tannic acid were added to increase the nitrogen and carbon levels to those typically found in domestic wastewater (table 1). The flow was adjusted to operate the system at 1 day of hydraulic retention time.

Ion-selective electrodes were used to measure N-$NH_3$, N-$NO_3$, N-$NO_2$; phosphate, sulfate, and chloride were measured by ion chromatography. Total organic carbon (TOC) was measured using a TOC analyzer, Shimadzu model TOC-5000; pH and Eh were also measured. The monitoring of the water was performed according to techniques described in the Standard Methods (American

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*Citation for proceedings*: Holland, Marjorie M.; Warren, Melvin L.; Stanturf, John A., eds. 2002. Proceedings of a conference on sustainability of wetlands and water resources: how well can riverine wetlands continue to support society into the 21st century? Gen. Tech. Rep. SRS-50. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 191 p.

**Table 1—Typical water-quality parameters in domestic wastewater**

| Parameter | Sewage in North America medium-strong | Experimental wetland[a] April-May 2000 |
|---|---|---|
| | Mg/L | |
| TSS | 720 – 1200 | 6.5 – 14.5 |
| TOC | 160 – 290 | 110 – 155 |
| $N\text{-}NH_3$ | 25 – 50 | 70 – 180 |
| $N\text{-}NO_3$ | 0 – 0 | 60 – 170 |
| $N\text{-}NO_2$ | 0 – 0 | 1.2 – 11.16 |
| pH | 6 – 8 | 6.9 – 8.1 |
| Phosphate | 5 – 10 | 25 – 75 |
| Sulfate | 30 – 50 | 600 – 620 |
| Chloride | 50 – 100 | 43 – 57 |

[a] Metcalf and Eddy 1991.

Public Health Association and others 1998). The parameters were measured in input and output water of the cells.

The simulated wastewater was prepared to meet the usual characteristics of sewage as shown in table 1 (Metcalf and Eddy 1991).

## RESULTS AND DISCUSSION

The experiment shows that the calla lily can grow very well on crushed rock beds at warm temperatures. The growth of the plants was faster than expected, and the plants started flowering after 6 weeks of plantation.

Ammonia and nitrate measurements showed that the wetland removed ammonia (fig. 1), but nitrate reduction occurred only at the beginning of the experiment before the addition of organic nitrogen (fig. 2). In fact, once fertilizer was added, the nitrate concentration was higher in the output than in the input water. This probably means that the production of nitrate by the conversion of organic nitrogen into ammonia followed by conversion of the ammonia to nitrate exceeded the nitrate removal capability of the system. In other words, the concentration of nitrate increases because of the lower capability of the system for denitrification than for mineralization and nitrification. It is necessary to quantify organic nitrogen to support this hypothesis.

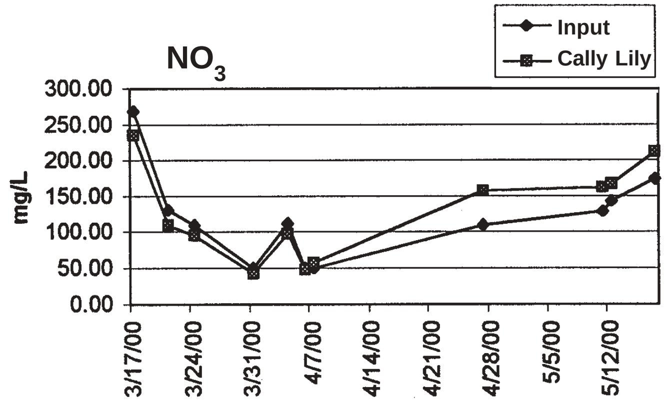


Figure 2—Nitrate concentration in mg/L.

Nitrite was found in very low concentrations compared with nitrate and ammonia; therefore, nitrate and ammonia are more descriptive of the nitrogen transformation in the artificial wetland.

Measurements of pH showed that the output water from the wetland had a quite constant pH, slightly higher than 7, even when the input water pH changed with time for almost 2 units (fig. 3). The redox potential (Eh) in the input and output water was very similar through the sampling period (fig. 4). This parameter showed a tendency of decrease with time throughout the duration of the experiment. This is probably due to the addition of organic nitrogen, ammonia, and organic carbon to the input water.

## CONCLUSIONS

Calla lily plants can live and grow very well in subsurface flow beds of crushed rock. In warm places, the calla lily can be used in subsurface flow wetlands to treat wastewater and produce cut flowers. This adds a financial benefit to the environmental benefit of wastewater treatment. Under proper

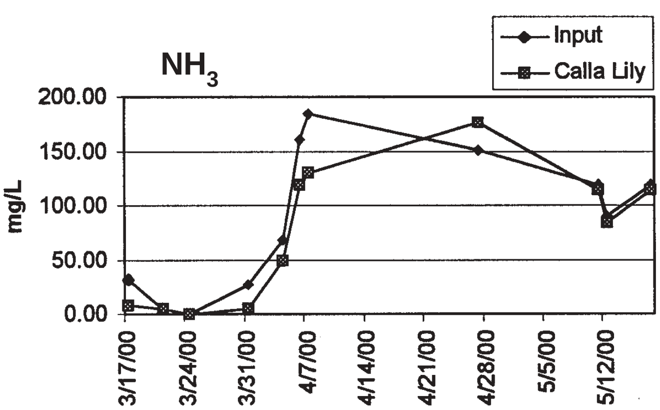


Figure 1—Ammonia concentration in mg/L.

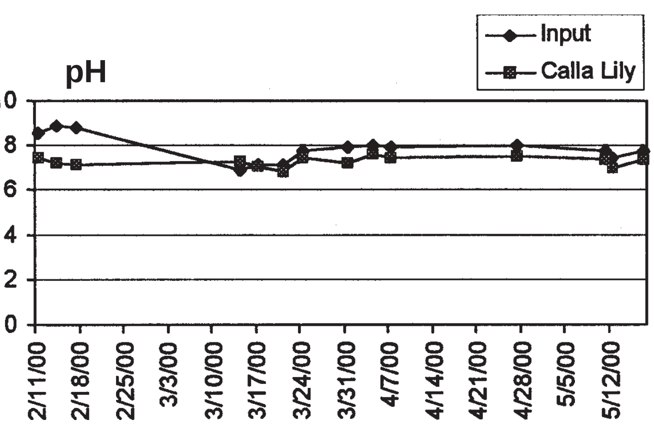


Figure 3—Measured pH.

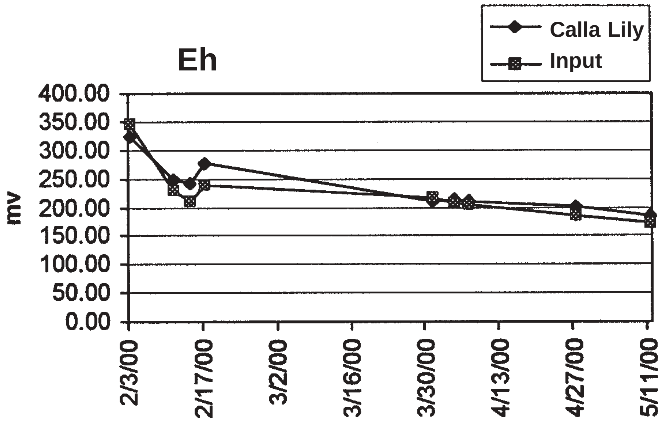


Figure 4—Redox potential (Eh) in mV.

conditions of hydraulic retention time, calla lilies can be used in subsurface flow wetlands to reduce levels of nitrogen and to convert ammonia to nitrate.

For the next phase of the experiment, it is necessary to quantify total organic nitrogen. The artificial wetland regulates the water pH buffering changes in the input water pH.

## ACKNOWLEDGMENTS

We thank the Canadian International Development Agency for the financial support received through the INSTRUCT project and Consejo Nacional de Ciencia y Tecnologia (CONACyT, Mexico).

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