The Effect of Two Plants Grown in Calcined Clay/Alumina on Nitrogen and Phosphorus Removal in Greenhouse Natural Swimming Pool Mesocosms

Dr. Margaret C. Hoffman
Western Illinois University
mc-hoffman@wiu.edu

Dr. Rob Berghage
The Pennsylvania State University
rdb4@psu.edu

Objectives

Two ornamental wetland plants, *Iris versicolor* and *Canna x generalis*, were tested for their ability to produce aboveground biomass in the low nutrient environment of a natural swimming pool (NSP) and for their N and P removal capabilities. A substrate of calcined clay, sand and alumina, was assessed for plant establishment and nutrient storage. This study also included a mass balance determination of substrate and water storage, biomass removal and unaccounted removal compartments. Nutrients of interest were NO_3 and P.

Methods

The experiment included 24 units and 3 treatments (*Iris virginica*, *Canna x generalis*, unvegetated), with 8 units each. NO_3 was measured weekly. Water P levels measured every 2 weeks using Murphy-Riley method. Biomass was weighed before planting and after completion of the study, Plant tissue P % was determined using dry ash method in Miller (1998)[1], and N% using the combustion methods in Horneck and Miller (1998)[2]. TN analysis conducted using the combustion method from Bremner (1996)[3], and P analyzed using the Mehlich 3 extraction method[4]

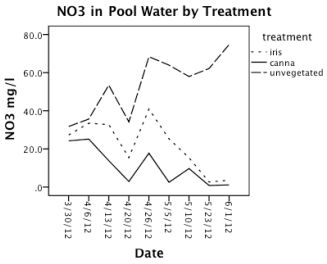
Conclusions

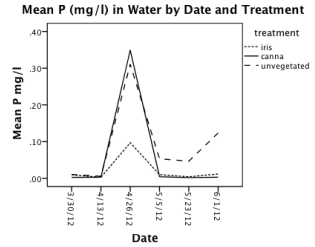
This research concludes a substrate of calcined clay/activated alumina is an effective media for adsorption of P in a NSP system. All treatments, C*anna x generalis*, *Iris versicolor* and unvegetated, reached treatment goals for P removal, P < .01 mg/l, and experienced > 99% removal of influent P. The vegetated treatments effectively removed 96% of influent N, but the unvegetated control did not meet the NO_3 treatment standard of < 30 mg/l NO_3. Treatment effect for plant species and final NO_3 levels in the pool water were highly significant with a p value < .001. Canna removed larger amounts of NO_3 than iris, probably due to greater biomass production. The correlation of biomass and NO_3 removal was highly significant, p<.001, using Pearson's correlation. Above ground biomass was a significant storage compartment in both canna sp. and blue flag iris, demonstrating the importance of harvestable biomass removal. It is clear from this research that vegetated filters improve nutrient removal and are crucial for attainment of N removal standards. This research demonstrates that the tested ornamental wetland plants, perform well in the low nutrient environment of a NSP and substantially improve biological filtration.

What is a Natural Swimming Pool?

Natural swimming pools (NSPs) are recent technological introductions to North America, designed to provide an attractive landscape amenity that also serves as a chemical free swimming pool, NSPs use biological filtration, a designed, intentional hydraulic system, and an impermeable liner to separate the system from the surrounding natural hydrologic cycle. Biological filtration involves the use of plants and substrate to closely replicate natural wetland environments.

Nutrient Removal





Final N and P (mg/l) in water		
Treatment	NO_3 (ave/SD)	P ave/SD
iris	3.6+/-5.4	.001+/-.001
canna	1.13+/-.87	0+/-0
unvegetated	74.8+/-8.6	.01+/-.007

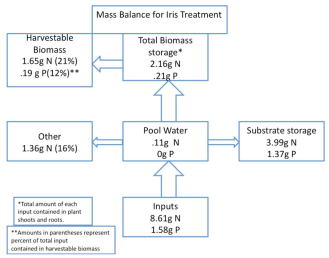
Shoot Nutrient Percent,Nutrient Content and Percent of Fertilizer input Removed by Harvest of Shoot Biomass

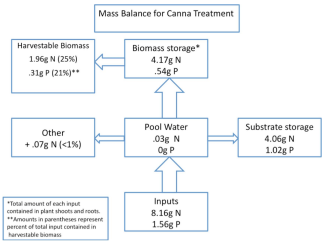
	Shoot percent		shoot N(g)	shoot P(g)	% of nutrient total in shoots		Percent of inputs removed by	
treatment	N%	P%	N	P	N	P	N	P
iris	1.88+-.13	0.21+-.05	1.65+-1.1	.18+-.06	76.39	85.71	59	13
canna	1.6+-.25	0.17+-.02	2.54+-1.1	.38+-.18	60.91	70.37	91	27

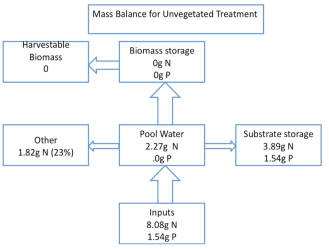
% removed by harvest=g of nutrient in shoot/mg/l of N and P from fertilizer

Photo courtesy of Hoffmans Gardens by Design

Mass Balance Analysis







For the purpose of this analysis the unaccounted P was applied to substrate storage compartments. Differences in percent removal are presented below.

Table 2: N and P Mass Balance (% input) with Unaccounted P

	Plant Uptake		Substrate Storage		Water Column		Other Losses	
Plant spp.	N	P	N	P	N	P	N	P
Iris	25	14	46	22	1	0	27	64
Canna	51	34	49	18	0	0	0	48
unvegetated	0	0	48	23	29	0	23	77

Table 3: N and P Mass Balance (% input) with unaccounted P as Substrate

	Plant Uptake		Substrate Storage		Water Column		Other Losses	
Plant spp.	N	P	N	P	N	P	N	P
Iris	25	14	46	87	1	0	27	0
Canna	51	34	49	68	0	0	0	0
unvegetated	0	0	48	100	29	0	23	0

This research was completed at Penn State as part of the requirements for Dr. Hoffman's doctoral degree, obtained in Aug., 2014.
Dr. Rob Berghage was advisor for the project and instrumental in the completion of the research. Dr. Hoffman is presently teaching at Western Illinois University.

References

1. Miller, R.O., 1998. High-Temperature Oxidation: Dry Ashing. In Y. P. Kalra, ed. Handbook and Reference Methods for Plant Analysis. New York: CRC Press
2. Horneck, D.A. and R.O.M., 1998. Determination of total nitrogen in plant tissue. In Y. P. Kalra, ed. Handbook and Reference Methods for Plant Analysis. New York: CRC Press
3. Bremner, J.M.. 1996. Nitrogen-Total. p. 1085-1121. In D.L. Sparks (ed). Methods of Soil Analysis, Part 3. Chemical Methods. Soil Science Society of America Book Series Number 5. American Society of Agronomy, Madison, WI.
4. Recommended Soil Testing Procedures for the Northeastern United States 2009