Promoting Water Reuse in Virginia

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Introduction

Irrigation with reclaimed wastewater ("water reuse") is a common practice in regions with low rainfall (e.g., Arizona) or limited and sensitive water supplies (e.g., Florida) but has not been adopted to a great extent in Virginia, where regulations specifically for water reuse have not yet been promulgated.

The Department of Environmental Quality (DEQ), Virginia's regulating agency for wastewater and reclaimed water land application, has requested data to justify that irrigation with reclaimed water will not result in N and P impairment of groundwater.

The Hampton Roads Sanitation District (HRSD) treats 40 million gallons of wastewater per day from Norfolk, Portsmouth, and Virginia Beach at its Virginia Initiative Plant (VIP) in Norfolk.

The HRSD VIP employs a biological nutrient removal technology that results in an effluent containing low concentrations of N and P. The greatest concern is the potentially growth limiting concentrations of soluble salts in the reclaimed water.

HRSD is exploring the feasibility of marketing reclaimed water for irrigation of landscapes, but the benefits and potential detrimental effects on groundwater quality and plant growth and quality had not yet been demonstrated as of 2004.

2005 mean water quality data for potable (PW) and reclaimed (NPW) irrigation sources and groundwater standards (GW).

Parameter	Units	PW	NPW	GW
BOD_5	mg/L	<2	8.2	
TSS	mg/L	1.0	4.5	1000
EC	dS/m	0.27	1.5	
Na	mg/L	36	238	100
Cl	mg/L	16	317	50
TKN	mg/L	0.8	2.1	
NO_3-N	mg/L	0.6	5.2	5.0
TP	mg/L	0.25	0.42	
pH		7.53	7.00	6.5-9.0

Objectives

A joint study of Virginia Tech, Virginia Cooperative Extension, and the Hampton Roads Sanitation District was initiated at the HRSD VIP in 2004 to compare the effects of potable and reclaimed water on:

1. Soil chemical properties that may be affected by irrigation water of varying ionic composition
2. Turfgrass nutrient uptake, growth, and quality
3. Leaching of N and P

Materials and Methods

Plots were established in 2004 on constructed sand-based profiles 30 cm thick over a subgrade using sands that met U.S.G.A. specifications for putting greens. Plots were plumbed to deliver irrigation with potable (PW) or reclaimed (NPW) water.

Treatments

- Water source: PW and NPW
- Turfgrass species:
  - Creeping bentgrass (*Agrostis palustris* var. L-93)
  - Hybrid bermudagrass (*Cynodon dactylon x transvaalensis* var. Tifsport)
- Experimental Design: CRD, 3 reps/treatment

Fertilization

Fertilization and pest management practices followed industry standards for putting greens. Annual fertilizer rates were:

- Bentgrass – 2002 kg N ha^{-1}, 8 kg P ha^{-1}
- Bermudagrass 253 kg N ha^{-1}, 10 kg P ha^{-1}

Sampling and Analysis

Clippings were mowed and collected 3-4 times per week and dried in a forced-air oven at 19°C. Cumulative monthly dried clippings were weighed for biomass production and analyzed for nitrogen and P. Soil was collected from the plots in July 2004 and October 2005 (after 15 months of irrigation) and analyzed for soil chemical properties.

Leachate collection

Two lysimeters were installed in each plot to collect and transport leachate to end of plot where leachate was sampled monthly for analysis of inorganic N and P.

The lysimeters were constructed of 5-cm diameter PVC pipe whose collection area was an open trough made by cutting a 30-cm capped length of pipe longitudinally and filling with sand from the soil profile.

Irrigation

Irrigation was supplied according to grass species seasonal requirements to prevent moisture stress. Irrigation was supplied 3-4 times/week with pop-up sprinklers except when 6 mm rainfall was collected in a rain gauge during the previous 24-hr period.

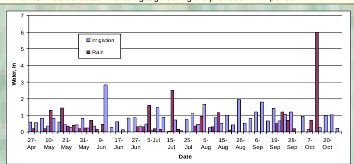


Fig. 1. Clipping yield of 'L-93' creeping bentgrass was higher with reclaimed water in 2005. Monthly treatment differences significant at 0.05 level of probability.

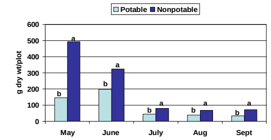


Fig. 2. Clipping yield of bermudagrass was lower with reclaimed water in 2005. Monthly treatment differences significant at 0.05 level of probability. NS = Not significant.

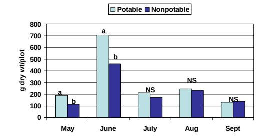


Fig. 3. Bermudagrass accumulated more biomass than bentgrass in 2005.

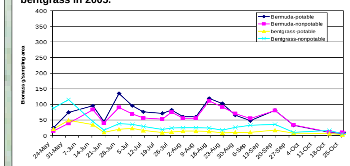


Fig. 4. Effects of irrigation source on visual quality of 'L-93' creeping bentgrass in 2005. 9 = highest and 0 = lowest quality. Monthly treatment differences significant at 0.05 level of probability. NS = not significant.

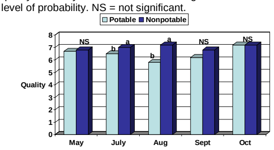


Fig. 5. Effects of irrigation water source on visual quality of 'Tifsport' hybrid bermudagrass in 2005. 9 = highest and 0 = lowest quality. Monthly treatment differences significant at 0.05 level of probability. NS = not significant.

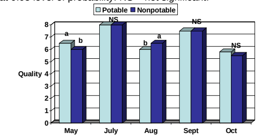


Fig. 6. Changes in turfgrass N concentration during 2005.

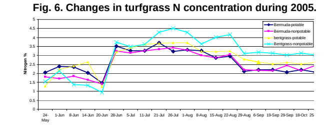


Fig. 7. Changes in turfgrass P concentration during 2005.

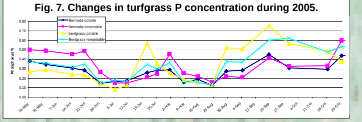


Table 1. Effects of irrigation source on N and P plant uptake.

	Bermuda	Bentgrass
	N uptake, kg/ha	
PW	453a	112d
NPW	335b	205c
	P uptake, kg/ha	
PW	44a	12c
NPW	41a	27b

Table 2. Effects of irrigation source on soil pH, P, base saturation and exchangeable Na percentage.

Soil property	July 2004	April 2006	
		PW	NPW
pH	5.87	5.40b	6.40a
mg Bray P/kg	6	17	13
BS (%)	77	72b	90a
ESP (%)	nd	7b	20a

Fig. 8. Higher concentrations of nitrate N were leached from bermudagrass than bentgrass in 2005.

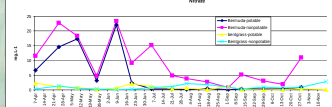


Fig. 9. Higher concentrations of ammonium N were leached from bermudagrass than bentgrass in 2005.

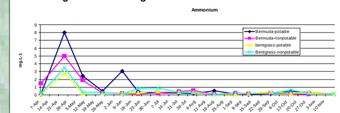
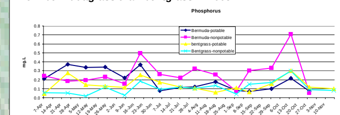


Fig. 10. Higher concentrations of ortho-phosphate were leached from bermudagrass than bentgrass in 2005.



Conclusions

- Although both grasses are moderately or highly salt tolerant when fully established and growing vigorously, the bermudagrass growth and quality appeared to be reduced by the high salt-containing reclaimed water upon breaking dormancy, and its N use during this period was also reduced.

- The bentgrass responded positively to the reclaimed water except during the initial establishment of the turfgrass, when the extra N favored shoot over root growth.

- Upon calculating the masses of N and P leached under the various irrigation sources x turfgrass types as the product of leachate volume and nutrient concentration, turfgrass or water source did not affect the mass of N and P lost to the lysimeters. The mean amounts of N and P lost via leaching during the May to October period were 21 kg N ha^{-1} and 3.4 kg P ha^{-1}.

- Routine irrigation with the HRSD VIP reclaimed water should not result in N and P impairment of ground or connecting surface water, but we recommend additional soluble salt removal (esp., Cl^- and Na^+) for long-term unrestricted use. Continuous use of reclaimed water of the quality used in the study appears to pose a long-term soil Na accumulation problem that may require regular occasional gypsum application.