Irrigation of Turfgrass With Secondary Municipal Sewage Effluent: Soil and Turf Aspects

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ABSTRACT

This field experiment evaluated the use of secondary municipal sewage effluent for irrigation of two turfgrass species. In April 1987 common bermudagrass (Cynodon dactylon L. Pers.) was seeded to a gravelly sandy loam soil and maintained under fairway conditions. Perennial ryegrass (Lolium perenne L.) was overseeded in the fall to maintain an actively growing turf. Plots were irrigated identically with either effluent or potable water. Soil and irrigation water samples were collected periodically and analyzed for pH, electrical conductivity (EC), sodium (Na), calcium + magnesium (Ca + Mg), bicarbonates (HCO_3), nitrogen (N), phosphorus (P) and potassium (K). Effluent water was found to contain a higher sodium absorption ratio (SAR), EC and greater concentrations of all the above elements with the exception of pH. Effluent irrigation lead to significantly lower seed germination and resulted in higher EC, Na, nitrate-nitrogen (NO_3-N), P and K concentrations in soils. Turf quality was assessed by visual evaluation under four N fertilization rates in each irrigation regime. Established effluent irrigated turf did not show signs of osmotic stress with a 15-20% leaching fraction and responded to the nutrient content of this water during periods of higher irrigation rates. However, no single fertilization rate or irrigation regime consistently produced a superior turf quality. Secondary municipal sewage effluent was used successfully for turf irrigation but the greater EC, Na and nutrient content of the water need to be considered by the turf professional making management decisions.

INTRODUCTION

Many populated areas in arid climates have a need for potable water conservation. Sewage effluent can be a valuable water and plant nutrient resource when used as irrigation for landscape and turfgrass plants. However, effluent is not of the same agricultural quality as potable water and its influence on soil can lead to decreased turf quality. Many recreational turf facilities in the southwestern United States already use reclaimed water for irrigation but special management practices have yet to be determined. Therefore, research is needed to evaluate how effluent use differs from potable water and what changes are produced in soil and plant properties.

Plant nutrients, Na and soluble salt concentrations (measured by EC) in secondary municipal sewage effluent differ from those in potable water (Table 1) and can be beneficial or hazardous to turf. The deposit of soluble salts into wastewaters from domestic and industrial use often deteriorates water quality for agricultural production. Soluble salts and exchangeable Na may induce severe osmotic stress on plants and lead to undesirable soil chemical and physical properties. Higher levels of N, P and K on the other hand, are important plant nutrients if supplied in the correct amounts.
The objective of this research was to investigate the suitability of secondary municipal sewage effluent for turfgrass irrigation. In order to identify practical management strategies, side by side field comparisons were made to potable irrigated turf managed under fairway conditions. The differences that effluent produced in soil and turf quality were identified and evaluated.

MATERIALS AND METHODS

This field experiment was conducted on an area adjacent to the Arthur Pack golf course 15 kilometers north of Tucson, AZ. The research ran 16 months from April 1987 to July 1988.

Two irrigation regimes, potable well water and secondary treated municipal sewage effluent, from the Ina Road Wastewater Treatment Plant in Tucson, were installed for on-site irrigation. Sprinkler heads were installed to irrigate six contiguous main plots (three replicates of each irrigation regime) each with an area of 92.9 square meters (1000 square feet).

Plots were irrigated identically with either effluent or potable water. Irrigation was managed to maximize turf growth and ranged from 1.3 centimeters (0.5 inches) to 5.3 centimeters (2.1 inches) per week. Total water applied was 1.5 meters per year (4.9 feet per year) which allowed for a leaching fraction of approximately 15 to 20% throughout the study. Irrigation rates were comparable to the adjacent golf course and other recreational turf facilities in the area.

Soil samples were collected prior to initiation of the study and thereafter at three-month intervals at a depth of 0.0 - 10.0 centimeters (0.0 - 4.0 inches). Visual turf quality ratings using a scale of 0 - 9 (0 = bare soil and 9 = excellent) were conducted on a monthly basis to document turf quality.

Common bermudagrass (Cynodon dactylon L. Pers) was seeded to the unfertilized soil on April 1987 at a rate of 73 kilograms (kg) per hectare (1.5 pounds (lbs) per 1000 square feet) and irrigated to establishment. During October 1987 perennial ryegrass (Lolium perenne L.) was overseeded at a rate of 732 kg per hectare (15 lbs per 1000 square feet) on all plots to maintain an actively growing turf during the winter.

Turfgrass was grown to compare the quality of effluent and potable irrigated turf subject to identical irrigation rates and applied N fertilizer. Application of N fertilizer began two months after seeding and rates were not reduced to compensate for nutrient inputs from the irrigation water. Commercial grade ammonium nitrate and urea were used to fertilize our subplots at 0.0, 16.1, 32.3 and 48.4 kg N per hectare per month (0.0, 0.3, 0.7 and 1.0 lbs N per 1000 square feet per month) on each of the six main plots in each irrigation regime.

RESULTS AND DISCUSSION

The use of secondary municipal sewage effluent for turf irrigation produced a different plant growth environment than potable water. This study showed that effluent-irrigated soils had greater concentrations of N, P, K, Na and elevated EC values (Table 2). In order to promote the highest quality turf, management professionals need a knowledge of the irrigation water properties and influences it can produce in the soil and plants.

Effluent water reduced seed germination approximately 5% for both turf species. This may require adjustments in seeding rates particularly for noncreeping turf species such as perennial ryegrass. Soil salinity did not reach levels that would limit the quality of these two turf species once they were established; however, adequate leaching did occur during the study. The sodium hazard to a soil is reported as exchangeable sodium percentage (ESP). Stroehlein and Pennington (Sulfur in Agriculture, Agron. 27. ASA-CSSA-SSSA. 1986) suggested that ESP values of seven to ten can lead to reduced water infiltration in finer-textured soils. Higher soil Na levels caused by effluent may require application of larger amounts of soil and/or water amendments such as gypsum or sulfur materials. Soils with large percentages of clay and high traffic areas may require these amendments and soil aerification on a more regular basis to maintain acceptable air and water permeability.
Effluent water had greater concentrations of N, P and K. This particular effluent contained approximately 225 kg N, 200 kg P and 150 kg K per hectare-meter (70 lb N, 55 lb P and 40 lb K per acre-foot). Nutrient inputs from potable water were, by comparison, insignificant. Soil NO_3-N levels were significantly greater with effluent when irrigation rates were high. Phosphorus levels in soils increased significantly over time indicating that effluent applied P in excess of plant needs. Soil K levels were also greater with effluent.

Turf quality varied considerably over the study period. However, there was no single fertilization rate or irrigation regime that was consistently superior (Table 3). Effluent plots did not show signs of osmotic stress from the greater salinity once turf was established and responded to the greater concentrations of nutrients as long as irrigation rates were relatively high. During winter months when irrigation rates were low, effluent plots receiving no additional N did not produce an acceptable quality turf. Plots receiving N fertilizer produced the best quality at this time. However, effluent plots receiving no N fertilizer produced the best quality of all research plots during summer months. Effluent plots that did receive N fertilizer showed signs of overfertilization, greater heat stress and iron chlorosis on overseeded ryegrass stands at this time. Overall, higher rates of N fertilizer produced the best quality when effluent irrigation rates were low but as irrigation rates increased, larger N fertilizer rates resulted in decreased turf quality. Potable plots, by comparison, did not show signs of overfertilization, chlorosis or severe heat stress. Potable plots had more consistent and predictable turf quality primarily because N inputs were not strongly influenced by irrigation rates.

Turf quality was influenced by nutrients in the effluent and, therefore, N fertilizer application could be decreased. The amount of decrease is dependent on seasonal irrigation rates and turf quality desired. The N level in secondary effluent was very consistent throughout the year and does not appear to be excessive for established turf. However, this N may contribute to unwanted bermudagrass competition and overfertilization of overseeded ryegrass during spring and fall transition periods. Application of commercial P fertilizer may not be necessary and should be minimized on established turf to reduce the potential for weed seed establishment and P-induced iron chlorosis. The nutrients in effluent should allow for a reduction or elimination of preseed soil fertilization. For best results, turf professionals need to be aware of the N, P, and K content of their effluent and the approximate amount of nutrients they add by way of the irrigation water. Turf managers should also monitor soil EC levels and Na concentrations to determine if additional leaching or amendments are necessary.

SUMMARY

Secondary municipal sewage effluent was used successfully as a source of irrigation water and plant nutrients for turf. However, management practices for effluent should compensate primarily for lower seed germination, greater salinity and the higher concentrations of N, P, K and Na produced in the soil. If effluent is managed like potable water, soil conditions may result that lead to a reduction in turf quality.

Table 1. Range of water quality for potable and effluent irrigation waters.

	Irrigation Regime	
	Potable	Effluent
pH	7.5 - 8.4	7.0 - 9.5
EC (dS m^{-1})	0.16 - 0.23	0.65 - 0.91
Na (mmoles$_c$ L^{-1})	0.6 - 1.3	3.5 - 4.9
Ca + Mg (mmoles$_c$ L^{-1})	0.6 - 0.9	1.0 - 1.5
SAR	0.7 - 1.6	3.2 - 4.1
PO_4-P (mg L^{-1})	< 0.05	6.4 - 26.8
K (mmoles$_c$ L^{-1})	0.02 - 0.10	0.19 - 0.43
NO_3-N (mg L^{-1})	1.0 - 5.0	1.0 - 7.5
NH_4-N (mg L^{-1})	0.0 - 1.5	0.0 - 28.6
CO_3 (mmoles$_c$ L^{-1})	0.0	0.0 - 1.1
HCO_3 (mmoles$_c$ L^{-1})	1.4 - 2.3	2.7 - 5.0
Fe (mg L^{-1})	< 0.10	< 0.10
Zn (mg L^{-1})	< 0.01	< 0.13
Cu (mg L^{-1})	< 0.05	< 0.05
Mn (mg L^{-1})	< 0.01	< 0.01

Table 2. Changes in chemical properties of soil due to irrigation regime.

	Irrigation Regime			
	Potable			Effluent
	original	final	original	final
pH	7.9a+	7.3a	7.9a	7.6a
EC (dS m^{-1})	0.7a	0.7a	0.9a	1.2b
Na (mmoles$_c$ L^{-1})	0.7a	2.3b	1.5c	8.3d
Ca + Mg (mmoles$_c$ L^{-1})	2.7a	0.8b	3.3a	1.3c
ESP	0.1a	0.8b	0.1a	7.6c
P (mg kg^{-1})	18.0a	4.3b16.0a	36.0c	
K (mg kg^{-1})	318a	199b	300a	333a

+Values in any given row followed by the same letter do not differ at the 5% significance level according to Student-Newman-Keuls Test.

Table 3. Turf quality+ using 48.4 (IV), 32.3 (III), 16.1 (II) and 0.0 (I) kg N ha^{-1} $month^{-1}$ under potable and effluent irrigation regimes.

	Irrigation Regime									
	Potable					Effluent				
	IV	III	II	I	Mean	IV	III	II	I	Mean
MAY 1987	2.0b	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3.9a	n.a
JUL	6.5a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5.0b	n.a.
AUG	6.7a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6.1b	n.a.
SEP	7.5a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6.7b	n.a.
OCT	8.5a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	8.1a	n.a.
DEC	4.0a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2.8a	n.a.
JAN 1988	5.8a	5.6a	6.0a	5.0a	5.6a	4.8b	4.5b	3.3c	2.0d	3.7b
FEB	6.5a	6.0a	5.8a	5.1b	5.9a	6.3a	6.2a	5.3b	3.5c	5.3b
MAR	7.6a	7.0ab	6.3b	5.4c	6.6a	7.0a	6.6a	5.9b	4.7c	6.1b
APR	7.5a	7.3a	6.0b	5.0b	6.5a	7.5a	7.2ab	6.5b	5.8b	6.8a
MAY	6.3b	6.2b	5.8b	4.8c	5.8b	7.4a	6.8a	7.1a	6.0b	6.8a
JUN	6.7b	6.3bc	6.7b	5.8c	6.4b	6.8b	7.3b	8.2a	8.6a	7.7a
JUL	4.6b	3.3c	5.5a	5.7a	4.8a	2.0c	2.4c	3.8b	5.9a	3.5b
AUG	5.2d	4.7d	4.5d	5.3d	4.9d	6.5c	6.8c	7.8b	88a	7.5b
MEAN	6.1a	5.8a	5.8a	5.3a	5.8a	6.0a	6.0a	6.0a	5.5a	5.9a

+Turf quality ratings were judged on a scale of 0 to 9 with 9 being best. Fertilization began June 1987.

+Values in a given row followed by the same letter do not differ at the 5% significance level according to Student-Newman-Keuls Test.

n.a. nonapplicable