Title: Comparison of soil properties and mineral composition of turfgrass shoots prior to and after 10 years of irrigation with effluent water

Investigator: Yaling Qian

Affiliation: Colorado State University

Objectives:

1) To determine chemical property changes of soil at 5 different depths prior to and 10 years after irrigation with effluent water.
2) To determine turfgrass mineral composition prior to and 10 years of irrigation with effluent water.
3) To determine soil ESP changes along soil profile (to 1 m deep) on fairways with gypsum treatment when compared to no gypsum treatment as the control.

Start Date: 2014

Project Duration: 2 years

Total Funding: $31150

Project Summary:

To determine the impacts of effluent water irrigation on turfgrasses and soils, it is difficult to conduct long-term field monitoring due to budget limitations. One opportunity for this project is that in 2004, PI collected soil and turfgrass baseline information for several landscape facilities (including 3 golf courses) prior to their use of effluent water for irrigation. All the sampling sites were marked physically. The original soil samples were archived for measurement comparison. Baseline data are available.

In 2009 and 2015, five years and eleven years after the initiation of recycled water for irrigation, soil samples were collected (to 1 m deep at 20 cm increments) again from the original sites to determine if any changes had occurred. Concurrently, Kentucky bluegrass clippings were collected for mineral analysis. In addition, soil exchangeable sodium percentage (ESP) and other parameters along the soil profile (1 m deep at 20 cm increments) on four locations that have been subjected to annual gypsum applications (aerify 1-2 times a year and apply gypsum at 50 lb/1000 sq ft/year) were sampled to compare to locations that did not receive gypsum application.

Results:

Soil analyses prior to and 10 years after effluent water irrigation indicated that soil sodium content, sodium exchangeable percentage, and soil pH increased after effluent water irrigation. One of the three golf courses had a significant increase in soil salinity (as gauged by soil electrical conductivity) in 2015 when compared to the benchmark baseline. The increase in soil salinity was not significant at other two golf courses. All three golf courses had increased soil pH. 2015 data indicated that the degree of soil pH increase was greater at deeper than at shallow soil depths (Fig. 1). In general, soil sodicity [as gauged by exchangeable sodium percentage (ESP)] was higher in 2009 and 2015 when compared to 2004.

Eleven years of effluent water irrigation has increased clipping sodium content by more than 4 times. Boron and chloride content increased, whereas tissue zinc content was reduced (Table 1). Despite the significant mineral content changes, turfgrasses generally exhibited good quality. However, there was a linear relationship between turf quality and sodium content in the clippings. We observed salinity stress on some localized sites with fine soil texture and poor drainage under effluent water irrigation.

For gypsum treated fairways, the increase in ESP from 2004 to 2009 at 0-20 cm and 20-40 cm depths were not statistically significant under effluent water irrigation (Figure 2 A). The increase became significant from 40 to 100 cm. The changes along the soil profile reflect sodium leaching that effectively prevented a significant increase in soil ESP at the shallow soil depths (0-40 cm). For control sites (effluent water irrigation with no gypsum treatment on site), the increases in ESP from 2004 to 2009 were significant at 0-60 cm depths, with ESP at the 0-20 and 20-40 cm depths being approximately tripled (Figure 2 B). The relatively high levels of sodium concentration relative to calcium and magnesium in effluent water resulted increased soil ESP, especially at the shallow soil depths (Figure 2 B). Although the gypsum treatment continued from 2009 to 2015, the wastewater treatment plant has also added calcium products to effluent water before the water leaves the treatment plant. As such, soil analysis exhibited reduced ESP at the surface depth for both treatments. Results from this study indicated that management (aggressive aerification and gypsum application)/or calcium product addition into effluent water helped to displace sodium and reduce ESP at the surface depth, although soil ESP increased significantly at deeper soil depths.

Summary Points:

- ✓ Turfgrass sites that have been irrigated with effluent water for 11 years exhibited an increased soil pH, soil ESP, and soil sodium content;
- ✓ Ten years of effluent water irrigation has increased Kentucky bluegrass clipping sodium content by more than 4 times. Boron and chloride content increased , whereas tissue zinc content was reduced.
- ✓ Despite the significant mineral content changes, turfgrasses generally exhibited acceptable quality. We observed salinity stress on some localized sites with fine soil texture and poor drainage under effluent water irrigation.
- ✓ Soil aerification and gypsum addition effectively prevented a dramatic increase in soil ESP at the shallow soil depths, although soil ESP increased significantly at deeper soil depths.
- ✓ The degree of soil pH increase under effluent water irrigaton was greater at deeper than at shallow soil depths

Table 1. Mean grass clipping ion concentrations of Kentucky bluegrass prior to and 11 years of irrigation with effluent water.

Parameters ($mg\ kg^{-1}$)	Prior to effluent water irrigation	After 10 years of effluent water irrigation
B	9.0**	17.7
Ca	3754	3425
Fe	296	387
K	19048	22642
Mg	1874	2725
Na	328***	1427
P	4915	5080
Zn	45.1	34.7
Cl	5207*	7545
K/Na	64***	17
Turf quality	8.2	7.6

*, **, *** Significant difference at $P \leq 0.05$, 0.005, and < 0.001, respectively.

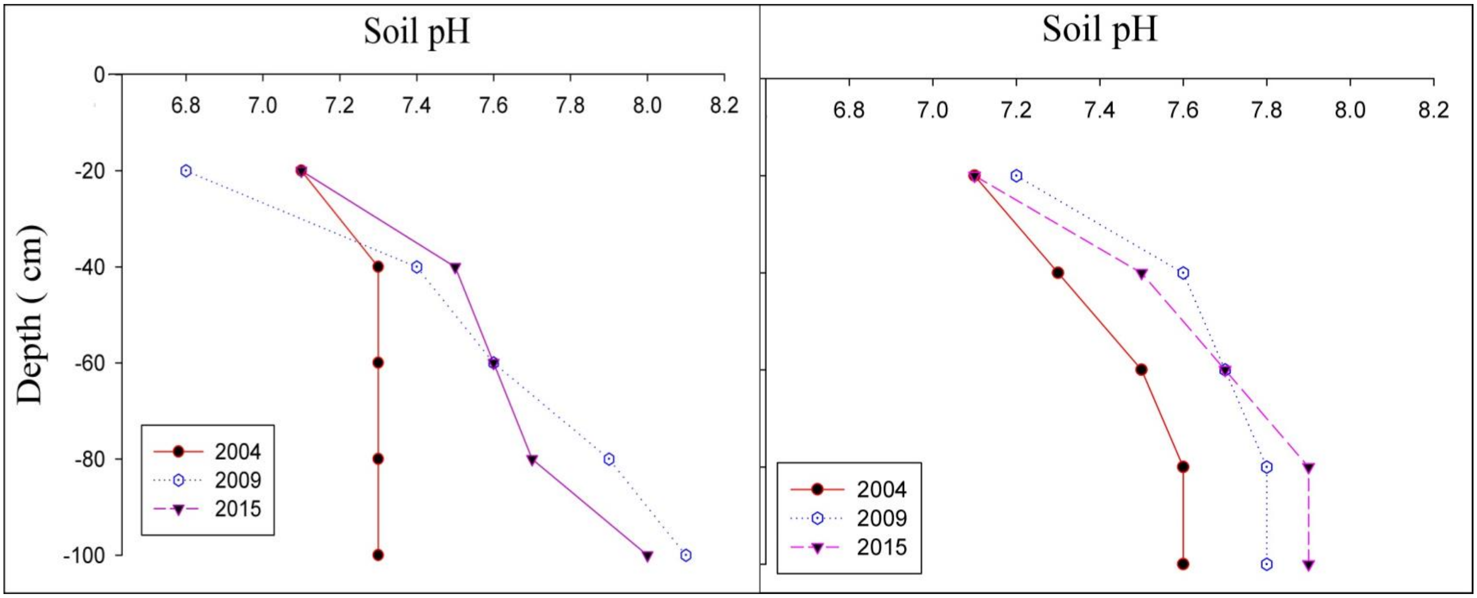
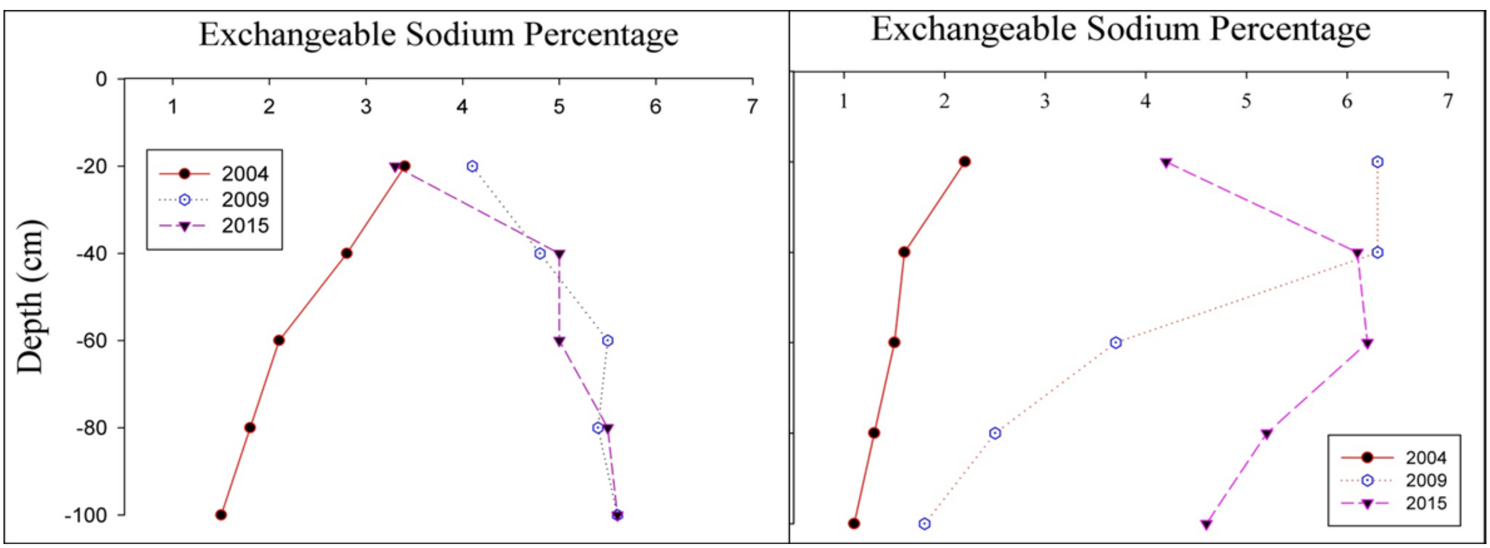


Figure 1: Soil pH at five soil depths at the initiation (2004), 5 years and 11 years after effluent water irrigation (2009 and 2015) on two golf courses. Each data point is the mean of 4 replications.



Fairways with Gypsum Additions **Fairways without Gypsum Additions**

Figure 2: Exchangeable sodium percentage at five soil depths at the initiation (2004) , 5 years and 11 years after effluent water irrigation (2009 and 2015). Each data point is the mean of 4 replications.