Water source effect on golf course soil quality in Oklahoma

Abstract

Reclaimed water use on golf courses is common in many areas of the Southwest United States, but is not common in Oklahoma. The objective of this study was to examine the effects of reclaimed water use on golf course soil quality in Oklahoma. This case study utilized soil and water quality samples collected from five golf courses in Oklahoma that used different water sources for turfgrass irrigation. This included Gaillardia Country Club, Quail Creek Country Club, Lincoln Park Golf Course, Lake Hefner Golf Course (all in Oklahoma City, OK) and the Jimmy Austin Golf Club (Norman, OK). The results from this case study indicate that irrigation water source (treated municipal water, untreated surface water, and groundwater) did affect soil test parameters, but there were not significant differences in nutrient and salt concentrations between certain parameters when irrigating with reclaimed water versus groundwater in Oklahoma. This case study data suggests reclaimed water can be beneficially used for golf course irrigation in Oklahoma in conjunction with supportive regulation and best management practices, such as aerification, leaching, choosing salt-tolerant turfgrass, applying proper applications of soil amendments, and consistently monitoring soil and irrigation water sources.

Introduction

Reclaimed water typically contains different levels of elements, such as nitrogen (N) and phosphorus (P), which can be beneficial to turfgrasses. Using the beneficial elements like N and P that already exist in reclaimed water can reduce the amount of fertilizers that golf courses use annually on their greens and fairways. In addition to these beneficial nutrients, reclaimed water can also contain high levels of total soluble salts, sodium (Na), and chloride, which can be damaging to plant and soil health. When using reclaimed water for irrigation, it is important to routinely monitor soil and water quality to properly manage the beneficial and harmful nutrients and elements.

Many of the studies that have been conducted on the use of reclaimed water for irrigation purposes have addressed use on golf courses in the southwest and arid regions of the United States (Hayes et al., 1990; Mancino and Pepper, 1992; Qian and Mecham, 2005; Lockett et al., 2008). Previous research has found that soil irrigated with reclaimed water contained elevated levels of soil electrical conductivity (EC), Na, macronutrients (N, P, K, Ca, P, Mg, and S), and micronutrients (Cl, Fe, Zn, B, and Mn) (Hayes et al., 1990; Mancino and Pepper, 1992; Qian and Mecham, 2005; Thomas et al., 2006; Lockett et al., 2008). Studies have also shown that proper irrigation management and soil and water monitoring can help balance out the excessive salts and nutrients. There is limited information regarding the effects of reclaimed water irrigation on soil chemical properties on golf courses in Oklahoma.

Currently in Oklahoma, reclaimed water is not used for golf course irrigation on a large scale. As drought conditions are frequent in Oklahoma, the use of reclaimed water for golf course irrigation is gaining interest from superintendents and municipalities. In this study, we examine the soil chemical properties of one golf course irrigated with reclaimed water in comparison to four other golf courses irrigated with different water sources (groundwater, untreated surface water, treated municipal water, and groundwater + reclaimed water mix).

Materials and Methods

This case study was conducted at five golf courses located in the Oklahoma City Metropolitan in central Oklahoma. Four of the five golf courses (Lincoln Park, Gaillardia, Quail Creek, and Lake Hefner) are located within Oklahoma City limits, and one golf course (Jimmie Austin OU) is located 25 miles south in Norman, Oklahoma. Each of the five golf courses uses a different water source to supply irrigation to their courses, including reclaimed water, treated municipal water, groundwater, and untreated surface water. The main soil series and texture classifications for each of the study sites was acquired through the assistance of the United States Department of Agriculture (USDA) and Natural Resources Conservation Service (NRCS) Web Soil Survey located in Table 1. The average annual precipitation for the central Oklahoma region is approximately 36 inches (Oklahoma Climatological Survey, 2012). The following is a brief list of attributes for each golf course. Gaillardia Country Club is an 18 hole private country club located in Oklahoma City, OK and has been irrigated with reclaimed municipal water since 1996. Lake Hefner Golf Club is a 36 hole public golf course and is irrigated with raw water from Lake Hefner in Oklahoma City, OK. Lincoln Park Golf Course is a 36 hole public golf course and is irrigated with municipal water purchased from the City of Oklahoma City, OK. Quail Creek Golf Course and Country Club is a 18 hole private golf course and is irrigated with groundwater wells. Jimmie Austin Golf Course at the University of Oklahoma is an 18 hole golf course irrigated with a mixture of 85% reclaimed water from the City of Norman and 15% groundwater from wells.

Soil samples and irrigation water samples were collected over two growing seasons at these golf courses and analyzed for the following parameters. The soil samples went through a soil fertility test, including the following parameters: pH, Soil Test Phosphorus (STP), Soil Test Potassium (STK), Surface Nitrate (NO_3), Surface Sulfur (S), Calcium (Ca), Magnesium (Mg), Iron (Fe), Zinc (Zn), Boron (B), and soil organic matter content (OM%). The soil samples also received a salinity management test (1:1 extraction), including the following parameters: Electrical Conductivity (EC), Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium (K), Boron (B), Total Soluble Salts (TSS), Sodium Adsorption Ratio (SAR), and Exchangeable Sodium Percentage (ESP). The irrigation water samples were tested for basic irrigation water quality and salinity management tests included pH, CO_3, HCO_3, EC, Na, Ca, Mg, K, B, NO_3-N, Cl, SO_4, Zn, Cu, Mn, Fe, NH_4-N, Hardness, Alkalinity, TSS, PAR, SAR, EPP, and ESP.

Statistical analysis was conducted to assess the interactions and effects of the independent variables (irrigation water sources and golf course greens, fairways, and non-irrigated roughs) on the dependent variables (soil chemical parameters) using Statistical Analysis Systems Software version 9.3 (SAS, Cary, NC, 27513) for the personal computer. An Analysis of Variance (ANOVA) procedure was performed using SAS 9.3 software, applying the General Linear Models Procedure, PROC GLM. The two-way factorial ANOVA procedure included a main effects analysis of the treatment (water source) and location (greens, fairways, and non-irrigated roughs) as well as an interaction of the main effects, treatment by location. The mean values of the soil properties from the interaction of the main effects that were statistically different at a p-value of 0.001 indicate that the data are consistent with the hypothesis that all soil chemical parameter means are significantly different for reclaimed water irrigation sources compared to the other irrigation water sources. Not all results of this work will be presented due to the time limit of the oral presentation at the Irrigation Show and Educational Conference Technical Sessions.

Results and Discussion

This case study evaluated the soil chemical properties and water quality properties of reclaimed water irrigation compared to untreated surface water, groundwater, and treated municipal irrigation on golf courses in Oklahoma. The results from the water quality tests showed that the highest concentrations of salts (TSS and EC) were found in the reclaimed water samples from Gaillardia, which was expected, but

the reclaimed water source from Jimmie Austin OU contained half of the salt concentrations than that of Gaillardia's reclaimed water source. The nutrient concentrations varied amongst the water sources, with each of the water source results showing values above and below medium sufficiency ranges. Reclaimed water sources typically contain higher levels of P and NO_3-N, in which both of the reclaimed water sources contained the highest mean values for both of these nutrients The samples from the reclaimed water source from Jimmie Austin OU had the highest mean value for dissolved P, possibly resulting from only receiving secondary treatment before use. The samples from both of the reclaimed water sources had the highest mean values for NO_3-N, but both were within the normal range for irrigation water, 5-50 mg L^{-1}.

The results from soil quality tests suggest that the salts and nutrient concentrations from the interaction of water source and the location on each of the golf courses (greens, fairways, non-irrigated roughs) were not statistically different from each other for each soil chemical parameter for at least one of the golf course locations. The hypothesis for this case study that the chemical properties of soil irrigated with reclaimed water would be different from those chemical properties of soils irrigated from the other three water sources was proven false, as the soil chemical concentrations were different in value for all of the water sources, but not statistically different for the treatment by location interaction.

As the demand for potable water supplies increases among municipalities and industry, the use of reclaimed water for non-potable uses, such as landscape irrigation, will also increase. Golf courses are ideal candidates to use reclaimed water for irrigation purposes. Both opportunities and problems are evident when using reclaimed water for irrigation purposes. It is important to understand the constantly changing levels of soil chemical properties and water quality parameters when using reclaimed water for golf course irrigation. The results from this case study indicate that other water sources (treated municipal water, untreated surface water, and groundwater) are not different when discussing nutrient and salt concentrations, providing data that suggests reclaimed water can be beneficially used for golf course irrigation just as other water sources. Reclaimed water can be an effective source for golf course irrigation in Oklahoma in conjunction with supportive regulation and best management practices, such as aerification, leaching, choosing salt-tolerant turfgrass, applying proper applications of soil amendments, and consistently monitoring soil and irrigation water sources.

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