Nitrate leaching and nitrous oxide emissions from turfgrass irrigated with tailored water

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Introduction

Turfgrass is the largest irrigated crop in the US, exceeding the area covered by any other irrigated crop by over three times (Milesi et al., n.d.). Used widely in urban areas and for athletic facilities, turfgrass mitigates the heat island effect, reduces erosion, and improves the quality of life of residents. In areas with dry conditions, turfgrass requires regular irrigation. Considering that in New Mexico alone, the irrigation of agricultural crops accounts for over 70% of water withdrawals, landscape irrigation of turfgrass may be exacerbating these withdrawals (Longworth et al., 2010).

In addition to watering, nitrogen is often supplied to turfgrass via fertilizer, such as urea. Using tailored water, or treated effluent with $Ca(NO_3)_2$ added to increase the nitrate concentration to 15 mg L^-, is a mechanism through which both of these needs can be delivered to turf areas. Furthermore, using treated effluent conserves potable water for home use by residents.

A study was conducted at New Mexico State University to investigate whether or not using tailored water stimulates nitrous oxide emissions in established grasses. Nitrous oxide, an ozone-depleting greenhouse gas, is stimulated by synthetic fertilizer, and is emitted directly into the atmosphere from agricultural fields (Ravishankara et al, 2010). Considering the magnitude of turfgrass as a crop, nitrous oxide contributions from fertilized grass to the atmospheric concentration could be substantial. The experiment performed is designed to ascertain if watering with tailored water changes nitrous oxide emissions in comparison with grass that is fertilized monthly with urea at the same monthly fertilization rate.

Methods

The experiment was conducted during the summer of 2018 and was set up in a greenhouse to provide a controlled and consistent environment, devoid of precipitation and weather related variables. The turfgrass varieties used in the experiment were bermudagrass cultivar Princess 77 and buffalograss cultivar SWI2000, two popular and drought resistant grass types used in the southwest United States. Control pots were filled with native soil only, and had no grass cover. Grasses and the control received either a monthly urea fertilization and were watered either with potable water or with tailored water every two days. The tailored water in this study contained 15 ppm of nitrogen from added calcium nitrate to treated effluent water, which is 5 ppm higher than the recommended concentration from the EPA. The experimental set up was completely randomized with each treatment replicated three times. Whether or not the higher concentration facilitates nitrous oxide emissions is unknown.

Drainage samples were collected each day that watering occurred and combined into a weekly sample that was refrigerated. Each sample was then analyzed for nitrate and nitrite.

Every two weeks, gas samples were taken using a closed chamber method (Parkin et al., 2010). Nitrous oxide levels were determined using a gas chromatograph with an electron capture detector (GC-ECD). The concentrations were used to calculate the flux of nitrous oxide from the pots. The model used to calculate flux is

$$f_0 = \frac{(C_1 - C_0)^2}{[t_1 \times (2 \times C_1 - C_2 - C_0)]} \times ln[\frac{(C_1 - C_0)}{(C_2 - C_1)}]$$

where C_0, C_1, C_2 are gas concentrations (ppm) at times 0, 1, 2, and t_1 is the interval between gas sampling points (Parkin et al., 2010).

Results and Discussion

Nitrite concentrations in drainage were found to be under 1ppm. Nitrate concentrations are shown in Figure 1.

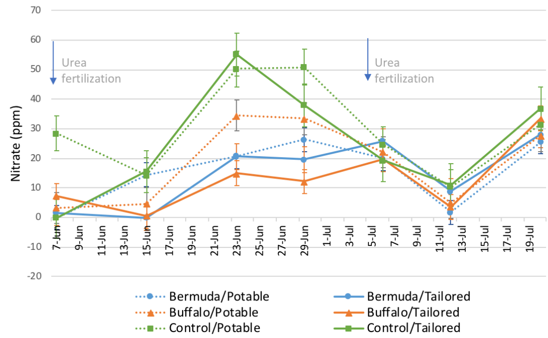

Figure 1. Nitrate concentrations in drainage during the study period. Date of urea fertilization of pots irrigated with potable water is denoted with vertical arrows.

Nitrate was found to vary by week, but showed an overall increase over the five weeks, perhaps due to the time it takes for nitrogen to move through the soil. Fertilization of the pots treated with potable water was not associated with a significant immediate increase in nitrate. Concentrations of nitrate in the control pots exceeded 50ppm during the third week, and were generally higher than the grass pots. Furthermore, statistical analysis revealed that only grass type affected nitrate concentration in the leachate (p-value = 0.00518). Irrigation water had no effect on nitrate leaching (p-value = 0.469).

Nitrous oxide concentrations are shown in Figure 2. The concentrations of nitrous oxide we measured were within the range of the nitrous oxide measured in ambient air. When data were analyzed statistically, there was neither a significant difference between the grass nor between fertilization in emissions output.

The flux we calculated (Figure 3) was often an order of magnitude higher than the 0.007258 $g/m^2/hr$ that Bremer reported in perennial ryegrass (Bremer, 2006).

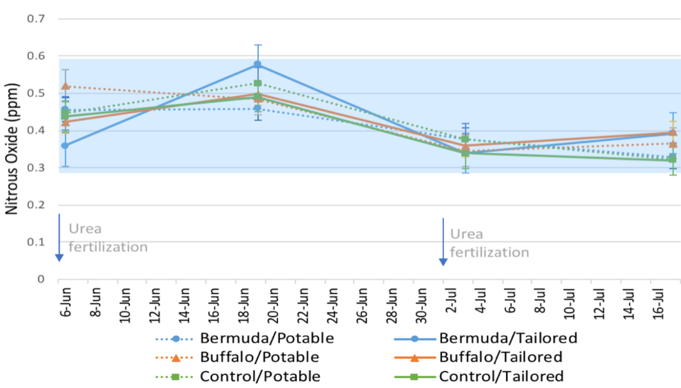

Figure 2. Nitrous oxide emissions during the study period. The blue range represents ambient nitrous oxide levels.

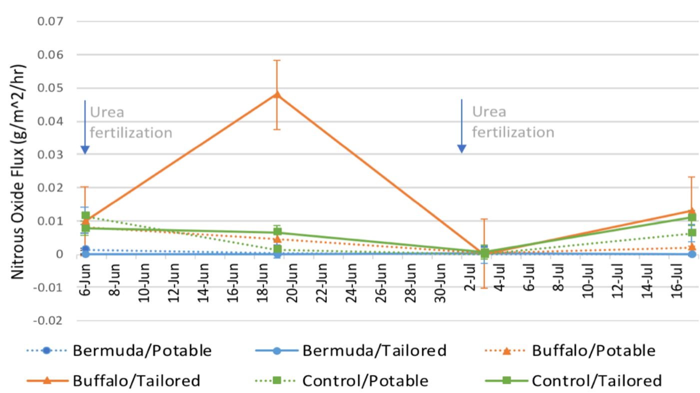

Figure 3. Nitrous oxide flux over time. Fertilization of potable pots with urea is denoted with vertical arrows

A point of interest was also whether development of a model to predict flux is possible. For each of the sample dates, a multiple regression model was developed in R Studio using the air temperature at sampling points, grass type, and irrigation type. For the first week, the model had a p-value of 0.00742. However, the second sampling week output a p-value of 0.2291, the third a p-value of 0.8605, and the fourth a p-value of 0.4806. This is indicative that we currently do not have a reliable mechanism to predict flux.

No difference is apparent between the irrigation waters in inducing nitrous oxide emissions. Ambient levels were maintained in our measurements. Additionally, nitrate concentrations do not appear to be impacted by irrigation type. This indicates that using tailored water is suitable in watering established turfgrass without causing additional nitrous oxide and nitrate output into the environment.

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