EVALUATION OF NITROGEN GAS LOSS FROM POLYMER COATED AND POLYMER SULFUR COATED UREA

Jeffrey D. Svedin, Curtis J. Ransom, Jessica C. Buss,
Trenton A. Blair, and Bryan G. Hopkins
Plant and Wildlife Sciences Department
Brigham Young University, Provo, UT; Hopkins@byu.edu

ABSTRACT

Previous research showed reduced nitrogen (N) gas emissions from polymer coated (PCU) and polymer sulfur coated urea (PSCU) when surface applied to soil. To further verify and quantify (N) loss, experiments were conducted to measure N gas emissions. Fertilizer prills were surface applied in a semi enclosed system to allow atmospheric gases in but to prevent loss of N gases from the headspace. Nitrous oxide (N_2O) and ammonia (NH_3) emissions were continuously measured every 20 minutes using photoacoustic infrared spectroscopy (PAIRS) for a period of 48 days. Cumulative PSCU and PCU N_2O emissions indicate 1.1 and 1.2 times less gas emissions compared to uncoated urea, respectively. Cumulative NH_3 volatilization loss was 3 times less than uncoated urea. In comparison, PCU reduced volatilization equal to the control, and 4.9 times less than uncoated urea. Indicating PCU's controlled release of N eliminates loss of fertilizer applied N through this mechanism; under these test conditions.

INTRODUCTION

Nitrogen fertilization is a common practice needed to maintain quality turfgrass. These applications often result in N loss to the atmosphere via N_2O emissions and NH_3 volatilization. The use of controlled and slow release fertilizers is a feasible method in decreasing N loss, as N is slowly made available allowing for more plant uptake. In addition, the slow/controlled release may reduce losses to the atmosphere.

While these products have been effective with agronomic crops, especially when incorporated in the soil, previous research indicated less than expected slow and control release properties from some products and the substantial deviation from expected release timing when surface applied to turfgrass under field conditions. Further research is needed to quantify N_2O and NH_3 emission for conventional and control release fertilizers, and then evaluate the effectiveness of PCU and PSCU in reducing N gas loss to conventional uncoated urea.

METHODS

An untreated control was compared to three fertilizer sources in a laboratory study. The fertilized treatments received application of 20 fertilizer prills at rates: 146 g N m^{-2} uncoated urea, 104 g N m^{-2} PCU (Duration 45™) and 111 g N m^{-2} PSCU (PCU and PSCU from Agrium Advanced Technologies, Loveland, CO, USA).

Treatments were surface applied to a Timpanogos Loam at 65% water filled pore space. The soil and treatments were

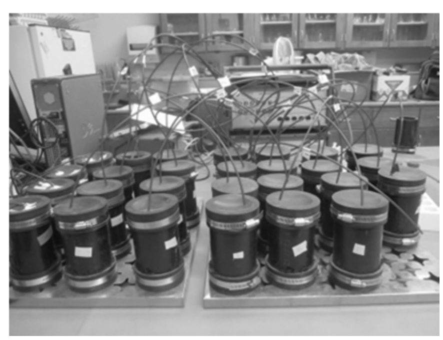

Figure 1: Semi enclosed system allowing capture of N gas emissions for sampling

incubated in a semi enclosed system under a constant temperature (Fig. 1). Soil was placed inside a 4.0 cm (1.57 in) diameter x 12.7 cm (5 in) long PVC cylinder nested inside a second PVC cylinder—7.7 cm (3.1 in) diameter x 15.3 cm (6.0 in) and retained with a porous "weed mat" fabric secured to and stretched across the bottom of the cylinder. The area in-between cylinders was filled with dry, medium sized quartz sand, which was retained with a rubber cap with small holes drilled into it to allow air flow into the bottom of the cylinders. The top of the outer cylinder was sealed with a rubber cap. The bottom of the cylinders were lifted off of the counter with a mesh screen that allowed air to flow into the cylinder. It was necessary to leave the bottom open to the atmosphere to allow headspace air replacement via flow upward through the sand, which was necessary to avoid creating a vacuum when the gas sampler evacuated the headspace for analysis. The entire headspace air was collected every 20 minutes using Innova 1309 multiplexer and analyzed for N_2O, NH_3, CO_2, and water vapor using an Innova 1412 Photoacoustic Field Gas analyzer (Lumasense Technologies, Santa Clara, CA, USA). Incubated soils were analyzed for residual soil nitrate (NO_3-N) and ammonium (NH_4-N) concentrations at the end of the study. The significance between treatment daily means was analyzed using ANOVA (P<0.05), with significant means separated using a Tukey-Kramer test.

Figure 2: 4 cm (1.57 in) diameter PVC cylinder nested within the 7.75cm (3.1 in) cylinder with sand filling the medium to allow for air flow during sampling.

RESULTS AND DISCUSSION

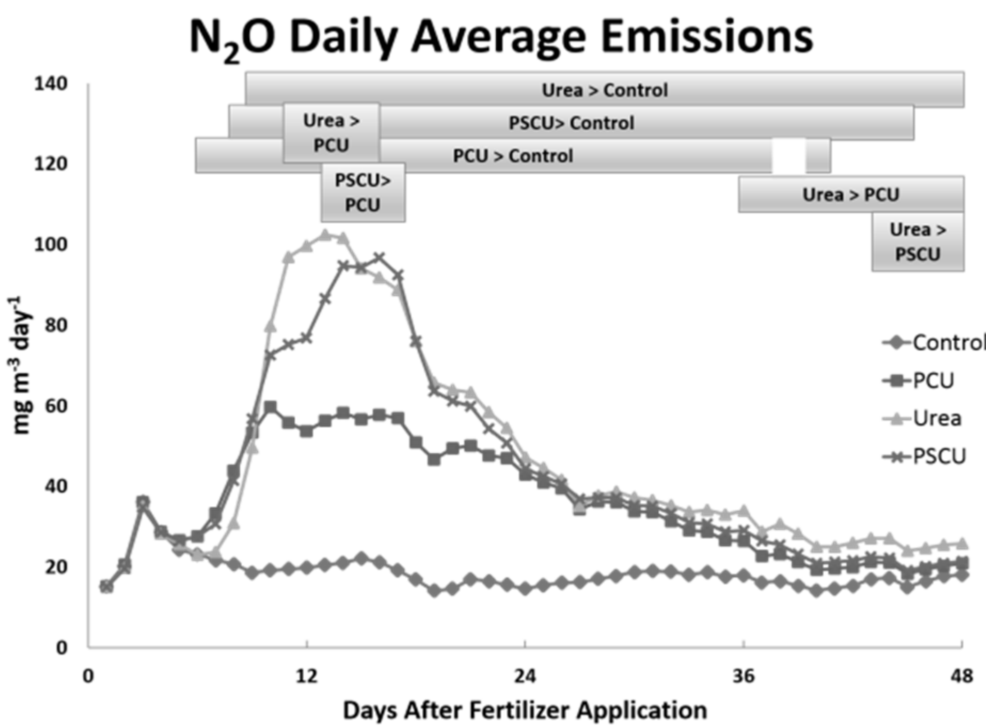

Figure 3: Daily concentrations of N_2O gas emissions from soils that have been treated with uncoated urea, PCU, PSCU fertilizers compared to an unfertilized control. Bars at top of graph represent days where the treatments were significantly different from each other (P<0.05).

Atmospheric Nitrogen

Cumulative PSCU N_2O and NH_3 volatilization emissions indicate a reduction in N gas loss compared to uncoated urea. Polymer sulfur coated urea N_2O emissions were 1.1 times less than uncoated urea but 2.3 times greater than the control. During the 48 day period PSCU's daily

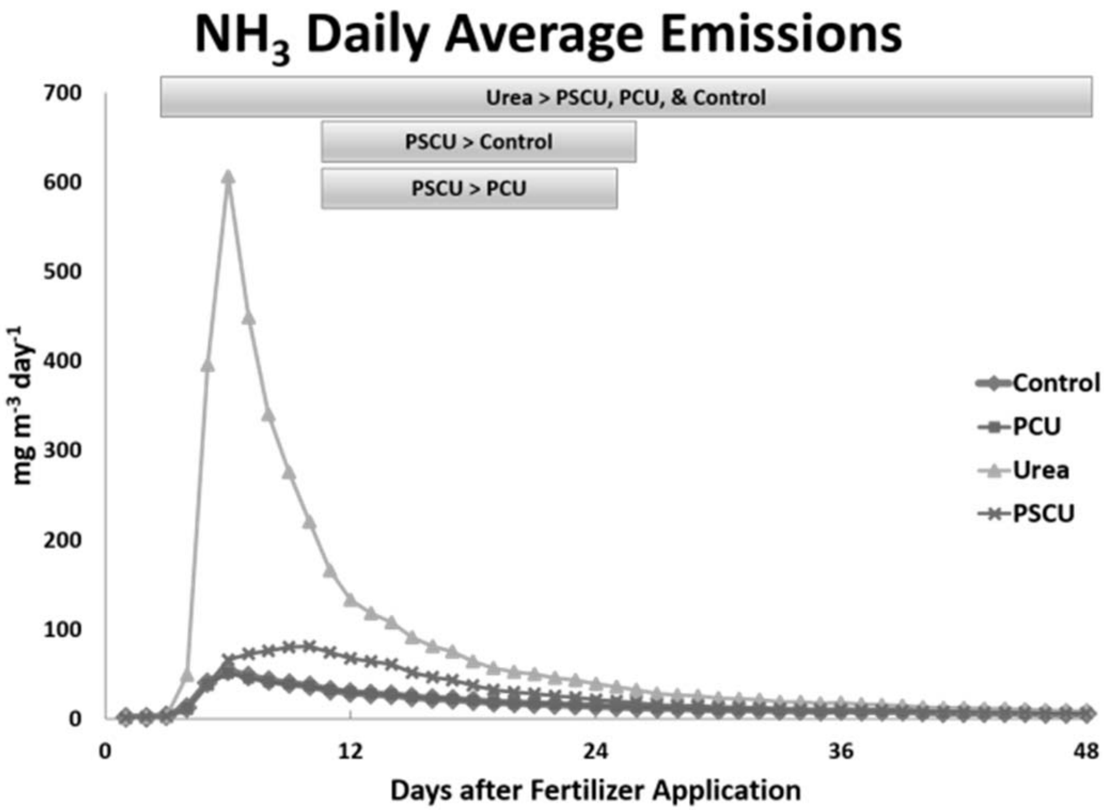

Figure 4: Cumulative concentrations of N_2O and NH_3 gas emissions from soils that have been treated with uncoated urea, PCU, and PSCU fertilizers compared to an unfertilized control. Letters on top of bars represent statistical difference from each other ($P<0.05$).

averages were greater than the untreated control on d 7-45 and then PCU on d 11-17; and less than urea on d 44-48 (Fig. 3). Polymer sulfur coated urea NH_3 volatilization was reduced by 3 times compared to uncoated urea. Volatilization daily averages were lower than uncoated urea on d 3-48 and greater than the control on d 11-26 (Fig. 4).

The daily NH_3 volatilization average for PCU was equal to the control for each of the 48 d measured (Fig. 4). In comparison to the uncoated urea, PCU resulted in less daily average emissions on d 3-48. The cumulative average of PCU over the 48 d measured showed a reduction in volatilization of 4.9 times compared to uncoated urea (Fig. 5).

Polymer coated urea N_2O daily emissions were greater than the control for d 7-31 with cumulative emissions 1.2 times greater than the control. Polymer coated urea daily N_2O emissions were less than uncoated urea 15 of the 48 total days (Fig. 4) with an overall 1.2 times less N_2O measured compared to the uncoated urea over the entire study period (Fig. 5).

Residual Soil Nitrogen

Polymer sulfur coated and PCU both contained 5.9 times less soil NH_4-N than uncoated urea and no increase compared to the control. Uncoated urea, PSCU, and PCU soil NO_3-N levels were greater than the control, but PSCU was greater than both PCU and uncoated urea (Fig. 6). This suggests that the slow release of N from PCU and PSCU is approximately equal with soil microbial activity which consumes a portion of the N.

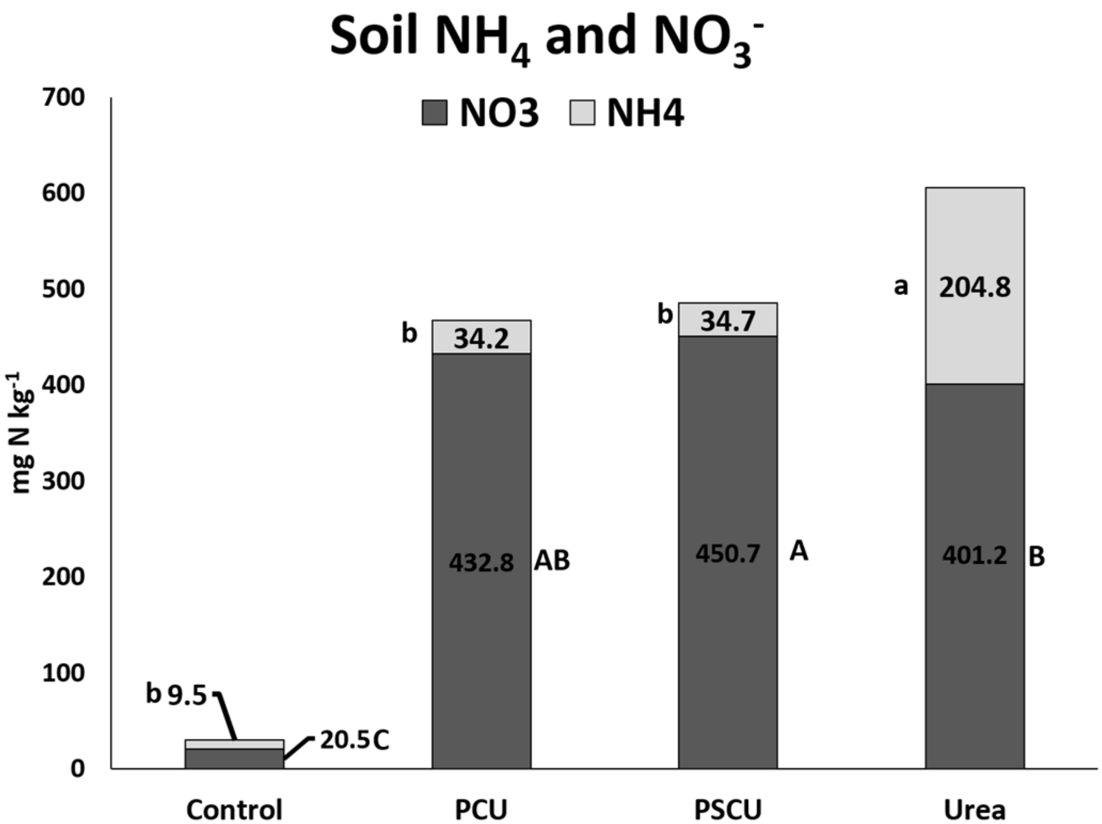

Figure 5: Cumulative concentrations of N2O and NH3 gas emissions from soils that have been treated with uncoated urea, PCU, and PSCU fertilizers compared to an unfertilized control. Letters on t op of bar s represent statistical difference.

Controlled Release Properties

Both PSCU and PCU demonstrated controlled/slow release properties compared to the uncoated urea, with a decrease of N_2O and NH_3 emissions. Similar to field research on turfgrass (Ransom, 2014), the increase of residual soil NO_3-N and significant higher emissions of N_2O and NH_3 in this study show that PSCU had less slow release properties than PCU. The patterns of denitrification and NH_3 volatilization from PSCU show a potential break down 7 d after application, resulting in N flooding the soil system similar, albeit slightly delayed, compared to the uncoated urea. While it is hypothesized that the prills degraded about one week after application, this provided enough time to reduce NH_3 emissions. In comparison, uncoated urea was quickly converted to NH_4^+ immediately flooding the environment creating favorable conditions for volatilization loss.

Overall the controlled release properties from PCU were more effective than PSCU, as there was a decrease in NH_3 emissions and no significant difference over the control. Furthermore a different pattern was seen for N_2O emissions in comparison to PSCU and uncoated urea with a reduced peak and a more level linear decrease of N_2O over time. An analysis of the N remaining in the prills indicated >90 % had been release into the soil solution during the study, an indicator that a longer study period will be needed to completely quantify gaseous loss from this product.

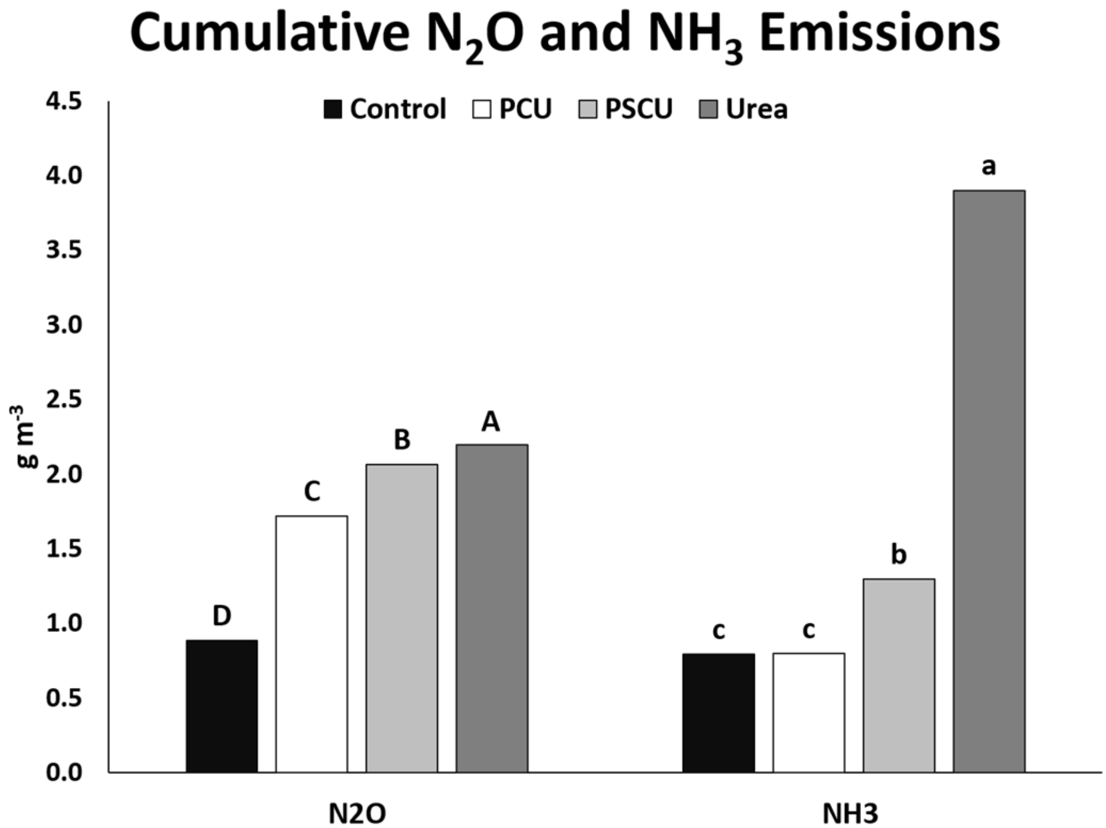

Figure 6: Individual treatment soil NO_3-N and NH_4-N levels 48 days after fertilizer application of PCU, PSCU, uncoated urea, and control. Letters next to bars represent statistical difference.

Extended analysis would show whether the pool of NO_3 would continue to denitrify or continue to decrease as indicated by the last 12 days of the study (Fig. 3). Denitrification microbes appear to be slowed, a result of soil becoming dry and forming unfavorable conditions for denitrification. Fertilizer applied to turfgrass would be actively up taken resulting in less N loss through denitrification. Further research must be done to completely understand time release and slow release N fertilizer gas properties within a living turfgrass system. An increase of NH_3 volatilization is expected to occur in turfgrass system as it is more prone to variation temperature, water, and chemical difference than in a laboratory setting. Tentative analysis accounted between 75-93% of applied N fertilizer.

SUMMARY

Polymer coated and PSCU were found to emit significantly less N_2O and NH_3 than uncoated urea. Polymer coated urea treatments acting similar to an unfertilized control in respect to NH_3 volatilization, indicating that in these conditions N loss was eliminated through this mechanism. Polymer sulfur coated urea also had reduced NH_3 volatilization, though not to the same efficiency as PCU. Nitrous oxide cumulative emissions were significantly reduced both by PSCU and PCU. Quantification of N_2O and NH_3 emissions supports previous research that polymer and sulfur coatings reduce applied N atmospheric gas loss. In this study PCU was more effective at reducing N gas loss; while this may be due to a shorter shelf life of PSCU, or quicker degradation of the polymer coating due to sulfuric acid build up.

REFERENCES

LeMonte, Joshua James, "Environmental Implications of Polymer Coated Urea" (2011). All Theses and Dissertations. Paper 3010 Brigham Young University.

Ransom, Curtis J., "Nitrogen Use Efficiency of Polymer-Coated Urea" (2014). All Theses and Dissertations. Paper 3985 Brigham Young University.

PROCEEDINGS
OF THE
WESTERN NUTRIENT
MANAGEMENT CONFERENCE

Volume 11

MARCH 5-6, 2015
RENO, NEVADA

Executive Committee
Galen Mooso, Simplot, 2014-15 Chairman
Joan Davenport, Washington State University, 2014-15 Vice Chairman
Jim Walworth, University of Arizona, 2014-2015 Secretary

Program Chair
David Tarkalson
USDA - ARS
3793 N 3600 E
Kimberly, ID 83341
(208) 423-6503
David.tarkalson@ars.usda.gov

Coordinator
Phyllis Pates
International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
ppates@ipni.net