Arsenic Retention in Foliage and Soil following MSMA Application to Turfgrass

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Introduction

Arsenic (As) is a particular element of concern in turfgrass systems. Organic arsenicals, such as monosodium methyl arsonate (MSMA), have been used since the 1960s are still used as herbicides for nuisance species of weeds in cotton and turfgrass systems today. Due to concern that As might leach into the subsurface and threaten the health of those who use groundwater as a drinking source, in 2009, the Environmental Protection Agency proposed a phaseout of organic arsenical pesticides to turfgrass to begin in 2013. Recently, the EPA conducted a subsequent scientific review and granted an extension, allowing MSMA to be used in turf systems beyond the 2013 deadline, pending additional research and analysis. Currently, MSMA is up for reregistration for cotton only. However, to date, little research has been done evaluating MSMA mobility in natural systems, and accordingly, the fate of As in turfgrass environments is not completely understood.

Experimental Objectives

- **Determine potential for leaching of MSMA to groundwater following MSMA application to bermudagrass and bareground soils**
- **Establish retention capacities for MSMA at our field site**
- **Analyze the loading limits of As on soils**

Methods

Field Setup

- Field lysimetry was used on 1.5 x 1.5 m bareground and bermudagrass-covered plots (Figure 1) at the Sandhills Research Station in Jackson Springs, NC.
- Soil-water samplers were placed through the center of lysimeters at a depth of 76.2 cm to measure dissolved As concentrations in porewater over time.
- MSMA was applied at Day 0; a sequential application was applied 8 days after initial treatment (DAIT).

Sampling and Analyses

- Depth profiles of total foliage and soil As concentrations were determined following hot acid digestions.
- Soil-porewater samples were collected over 334 days and analyzed using an ICP-MS with detection limits of 0.35 µg/L.
- Adsorption isotherm studies were performed on washed commercial play sand, Cecil clay loam soil (Alamance County, NC), and Candor sand from our field site.


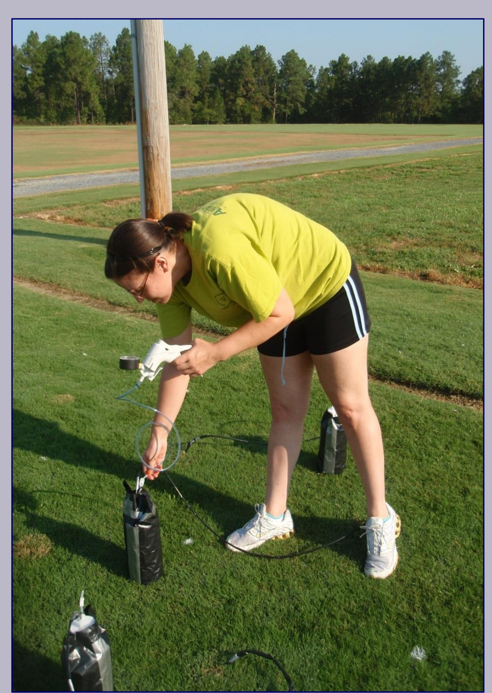
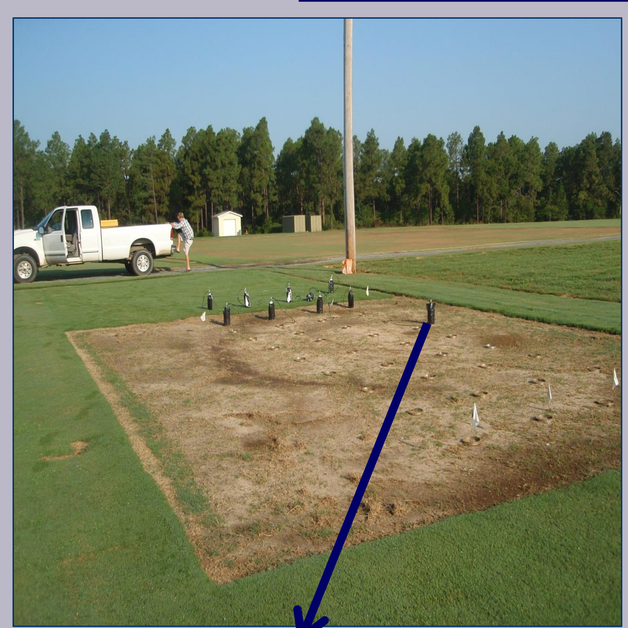
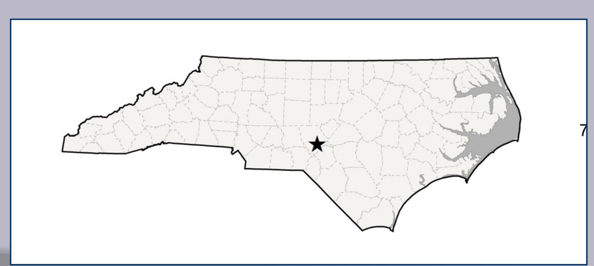
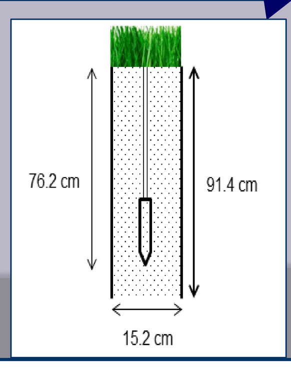

Figure 1: Field site location with lysimeter and porewater sampler setup.

Results

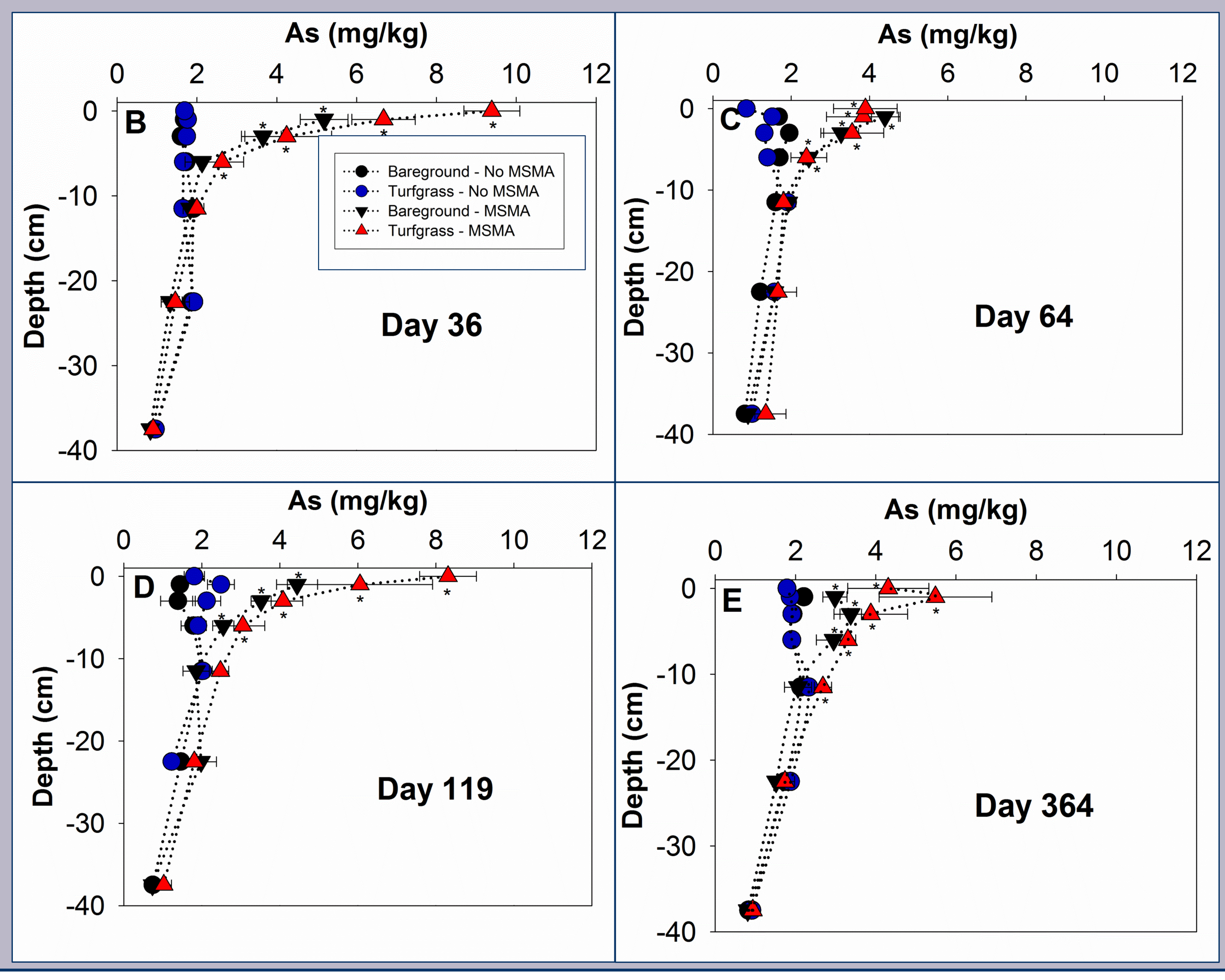

Figure 2: Depth profile of As in soil through 364 DAIT of MSMA. Lysimetry data found MSMA-treated plots contained the highest concentrations of As in the above-ground vegetation and surface soils (0-2 cm) through 364 days post application. Highest concentrations of As were found 36 DAIT. Near background levels of As was reached at most time points around 6 cm, indicating low levels of leaching through the profile. Error bars represent duplicate samples in no treatment samples, and quadruple samples for treated samples. Asterisks indicate As values from treated lysimeters which were significantly higher than equivalent depths in nontreated lysimeters.


Time (DAIT)	Turf or Bare	% As Recovered Soil	% As Recovered Foliage	Total % As Recovered
36	Turf	83%	10%	93%
36	Bare	62%	-	62%
64	Turf	47%	3%	50%
64	Bare	60%	-	60%
119	Turf	83%	9%	92%
119	Bare	66%	-	66%
364	Turf	98%	4%	101%
364	Bare	55%	-	55%

Table 1 : As recovery in lysimeters. Generally, more As was recovered in bermudagrass-covered lysimeters (50-101%) than in bareground lysimeters (55-66%). As recovery in foliage accounted for up to 10% of total As applied.

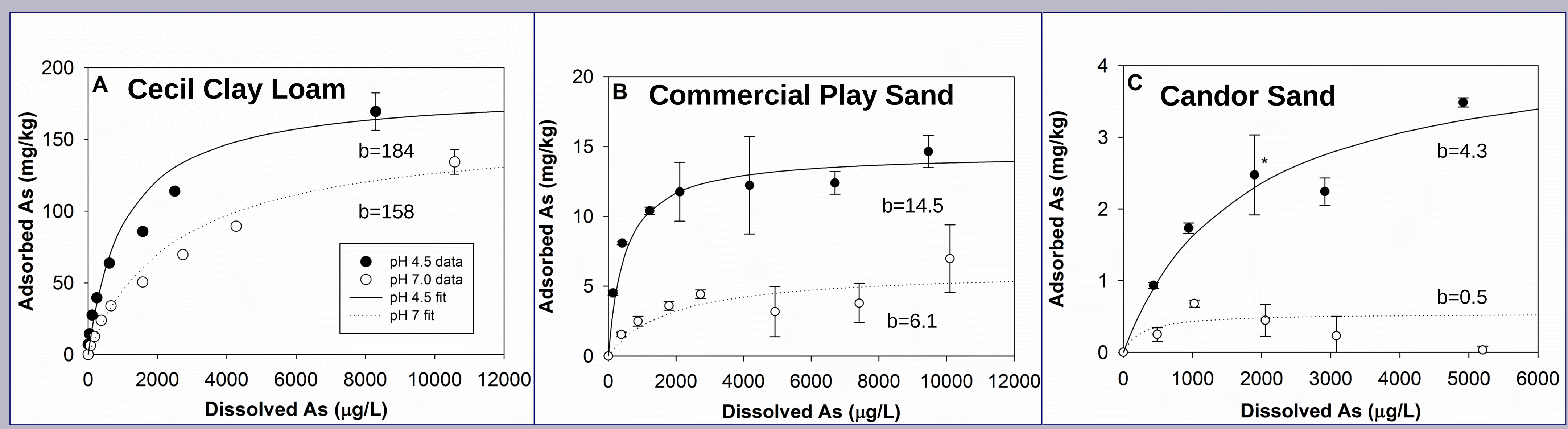

Figure 3: MSMA adsorption isotherm experiments. Significant quantities of As were adsorbed to the Cecil clay loam. Lowest binding of As was found in Candor sand from our field site, even lower than commercial play sand. 1M HCl extractions exhibited the highest As:Fe and P:Fe in the Candor sand, suggesting binding sites were filled prior to experimentation.

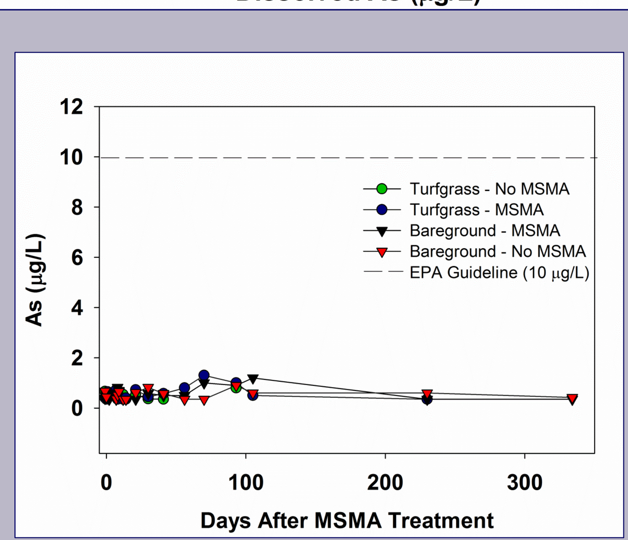

Figure 4: Porewater As concentrations. Concentrations of As in porewater were less than 2 µg/L in treated and non-treated samples through 300 days, suggesting that As was rather immobile in the unsaturated sandy soil at our site.

Summary and Implications

- In MSMA-treated lysimeters, elevated soil As concentrations were exhibited only down to 11.5 cm through 364 DAIT.
- Arsenic recovery in soil and foliage of turf-covered lysimeters was >90% for 3 of 4 sampling times.
- Maximum arsenic recovery in soil of bareground lysimeters was 66%.
- Maximum measured porewater concentrations of dissolved As (< 2 µg/L) were lower than the current EPA drinking-water limit.
- Laboratory adsorption studies showed strong binding of MSMA to soils with clay, but less so with sandy soils.
- The highest solid-phase As concentrations were found in the bermudagrass foliage, suggesting that MSMA is taken up by the grass, potentially cycling through the experimental system over time as the grass clippings were returned to the plots.
- Ongoing work is investigating As cycling in turfgrass clippings, As speciation changes, and As loading limits to soil.

Acknowledgements

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