Controls on Greenhouse Gas Emissions in Managed Soils

Whendee Silver*, Marcia DeLonge

Project Objectives

1. What are the effects of substrate quality on the emissions of CO₂, N₂O, and CH₄ from organically amended (compost and manure) grassland soils?
2. How do organic amendments affect soil temperature and moisture, and how do they feedback on greenhouse gas effluxes?
3. What is the net greenhouse gas balance from amended soils, and how important is the chemical quality of the organic amendments used?

Approach and Procedures

We are employing field and laboratory experiments to investigate the effects of organic amendments of variable chemical (carbon and nitrogen) quality on greenhouse gas (CO₂, N₂O, and CH₄) emissions. Field sites in actively grazed rangelands have been established on three ranches in Marin County, CA. Three treatments of organic amendments with different C:N ratios (two composts with different ratios of corn stover and manure, and one dairy manure) will be applied to replicate plots at each study site. Greenhouse gas emissions are being measured during all phases of the composting process and following application to soils. Net primary productivity of the grasslands and soil carbon pools will also be measured as part of the experiment. Temperature and moisture will be measured continuously throughout the project and the controls of these variables on trace gas emissions will be determined. Resulting datasets will be incorporated into a life-cycle assessment of organic amendments that will consider soil biogeochemical cycling in the larger context of material and energy flows.

Results

During the 16-week composting process soil CO₂ emissions averaged 281 ± 32 µg CO₂-C cm⁻² h⁻¹ from the compost piles compared to 350 ± 31 µg CO₂-C cm⁻² h⁻¹ from the manure pile (p = 0.01). The manure pile also had higher N₂O emissions (116 ± 24 ng N₂O-N cm⁻² h⁻¹ and 183 ± 33 ng N₂O-N cm⁻² h⁻¹ from the compost and manure piles, respectively), but the differences were not statistically significant. Methane emissions were slightly, but not significantly higher in the compost pile than in the manure pile (124 ± 26 ng CH₄-C cm⁻² h⁻¹ and 81 ± 23 ng CH₄-C cm⁻² h⁻¹ from the compost and manure piles, respectively).

The patterns of trace gas emissions over time differed among the three gases. Carbon dioxide emissions were greatest early in the experiment, and decreased significantly as temperatures
within the piles decreased. Nitrous oxide emissions were greatest later in the season, and CH₄ emissions showed little pattern over time (Fig. 1).

![Figure 1](image_url)

**Figure 1.** Fluxes of CO₂ (upper left), CH₄ (upper right), and N₂O (lower left) from organic amendments (corn-dominant compost, CC; manure-dominant compost, MC; and manure, MN) during a 16-week composting period. (lower right) Estimated total global warming potential of emissions from organic amendments with a surface area of ~70 m² during 16-week period.

During the composting period, total losses of carbon were largely from CO₂ for all piles and were not significantly different between piles (corn-dominant compost: 12 ± 3 kg CO₂-C m⁻², manure-dominant compost: 11 ± 3 kg CO₂-C m⁻², manure: 12 ± 2 kg CO₂-C m⁻²). Due to the larger global warming potential of CH₄ and N₂O relative to CO₂, however, the greatest global warming potential (IPCC 2007) from the emissions resulted from CH₄ losses (Fig. 1). We estimate that the total CH₄ emissions represented 73% of the global warming potential from both compost piles, but only 15% from the manure.

Initial soil C and N concentrations varied significantly across ranches, but not across plots within ranches. Initial soil C ranged from 2.7 to 5.3 % and initial N ranged from 0.22 to 0.49 % in the 0-10 cm depth. The C:N ratios of the surface soils were similar across sites ranging from 10-12.

**Discussion**

Our preliminary results show that composting can result in significant greenhouse gas emissions, exceeding that of source materials, including manure. Methane exhibited the largest global
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warming potential relative to CO₂ and N₂O. This likely results from the C-rich substrate and anaerobic conditions developing in the compost piles. Surprisingly, net CO₂ and N₂O fluxes were quite similar across the three materials, regardless of C and nutrient quality. Initial soil C and N were well within the range of other studies from this region (Silver et al. 2010). In the next phase of the experiment we will explore the effects of compost and manure amendments on C and nutrient cycling, NPP, and greenhouse gas emissions following application to soils.

This research is well aligned with the Kearney Foundation of Soil Science Mission to conduct management-relevant science that ranges from soil processes to ecosystem function. Early findings have revealed that significant greenhouse gas emissions occur during the composting process (including transportation, construction, and biological processing). These emissions will be considered in a life-cycle assessment of the net greenhouse gas emissions of organic amendments. High variability in source material and compost quality emphasizes the potential benefits of using modeling techniques to achieve a thorough assessment of the cost and benefits of such land management techniques.

References


Presentations:

Press Coverage
Commonwealth Club of San Francisco Oct 2010
Climate One Field Visit Dec 2010

Publications

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