Drying and Rewetting Effects on Gas Emissions from Dairy Manure in Semi-arid Regions

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Introduction

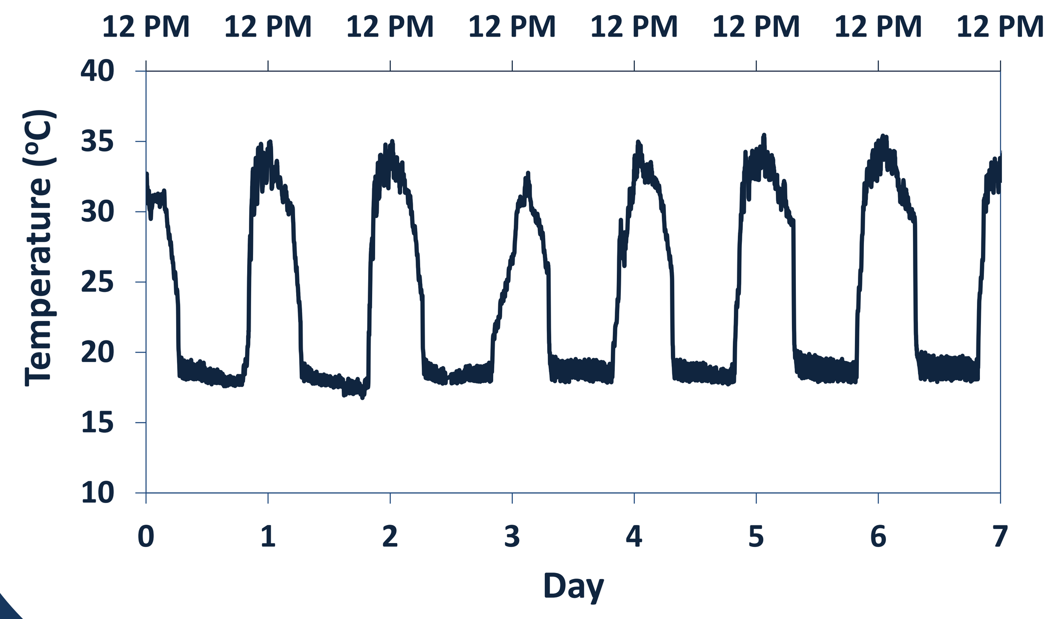
The major source of gaseous emissions from animal production sites is animal waste (manure) in solid, slurry, or liquid forms, exhibiting varying physical properties. Once manure is excreted from an animal, processes of biological decomposition and formation of gaseous compounds continue, but diminish as manure cools and dries. Animal manure and its common use as fertilizer contribute to gaseous emissions, significantly degrading air quality to the detriment of human health and the environment. Changes in gas emissions during drying and following rewetting, particularly from precipitation, have been observed in various agricultural settings.

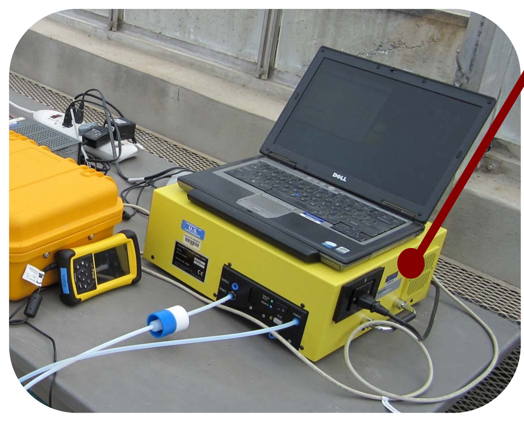
Dairy cattle on a typical feedlot (left). Animal waste, including bedding materials such as straw from the feedlot, is commonly collected and transported to a manure storage area (right) before being applied as fertilizer.

Our study investigates changes of gaseous emissions from manure-incorporated soils undergoing drying and rewetting processes to identify the effects of climatic conditions and manure management. The rewetting of dry manure-incorporated soil represents abrupt step changes in physical soil conditions, particularly changes in moisture content. We dried and rewetted dairy manure-incorporated soil in a greenhouse to maintain moderate summertime temperatures (15 - 40 °C), while monitoring gaseous emissions throughout these processes. Closed dynamic chambers (CDC) coupled with a multiplexed Fourier Transformed Infrared (FTIR) spectroscopy gas analyzer provided gas flux estimates. The results from our study will be used to advance development of appropriate best management practices to reduce gas emissions from dairy operations in semi-arid regions.

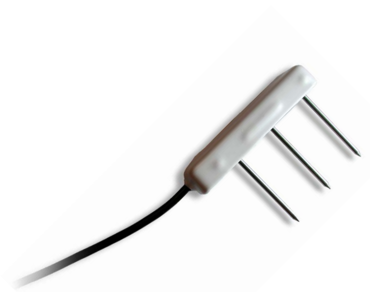
Experimental Design and Setup

Our investigation was conducted at the USU Research Greenhouse Complex (Logan, UT). The average temperatures during day and night times were 33 °C and 19 °C, respectively (see below). The dairy farm yard manure with straw bedding material, collected from the Caine Dairy Teaching and Research Center (Wellsville, UT), was applied and incorporated into soil with an application rate of 50 ton/acre. Gas emissions were monitored from the manure-incorporated soil using the CDC technique with a multiplexed FTIR gas analyzer. In addition, we examined changes in moisture content throughout the experiment.

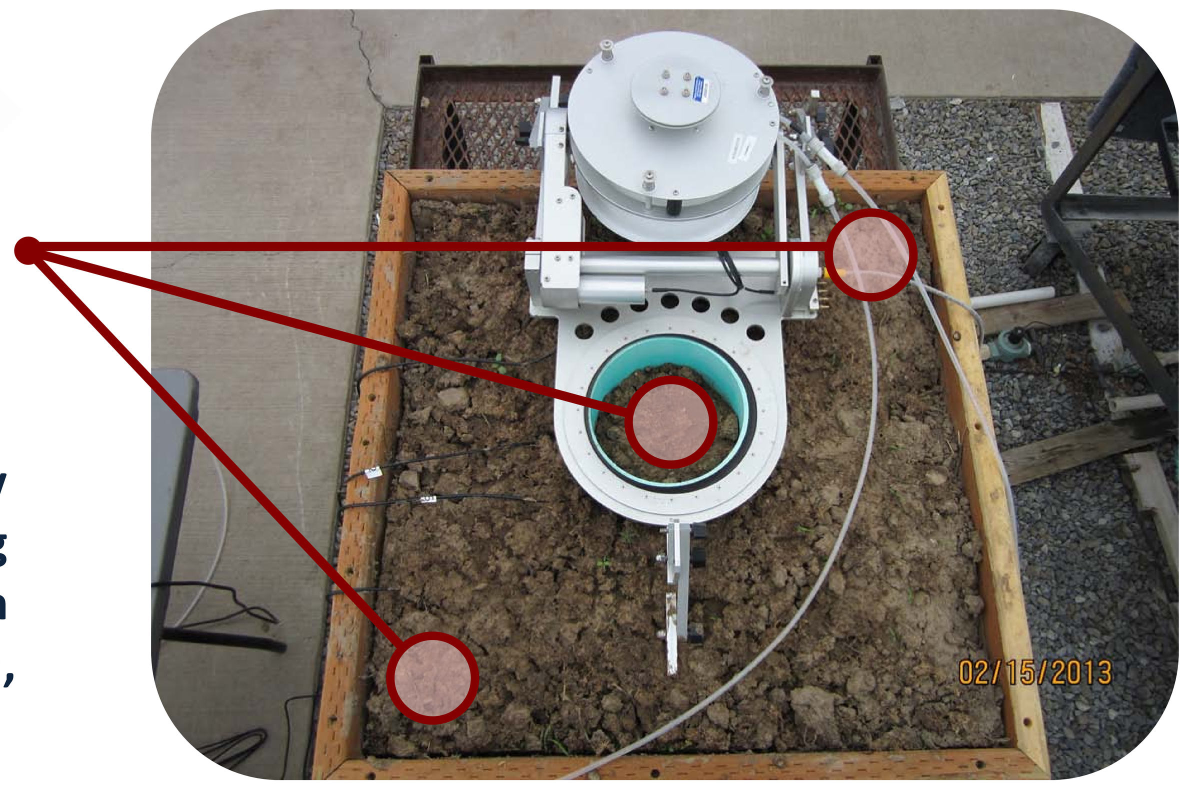




The Gasmet DX4030 FTIR gas analyzer (Gasmet Technology Oy, Helsinki, Finland) was capable of monitoring 15 pre-programmed gases simultaneously, including typical gaseous compounds and greenhouse gases emitted from manure sources; namely, ammonia (NH_3), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), oxides of nitrogen (NO_x), and volatile organic compounds (VOCs).

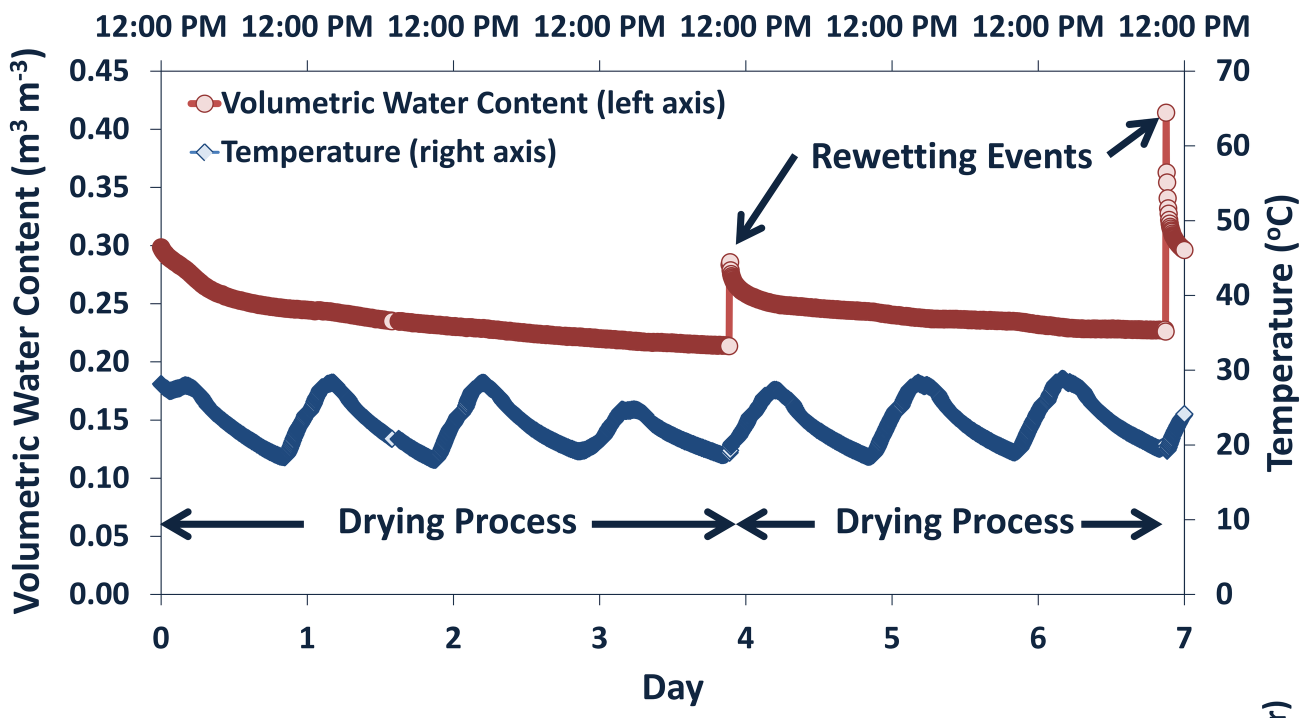


Soil water content, temperature, and electrical conductivity were monitored using GS3 Sensors (Decagon Devices, Inc., Pullman, WA).

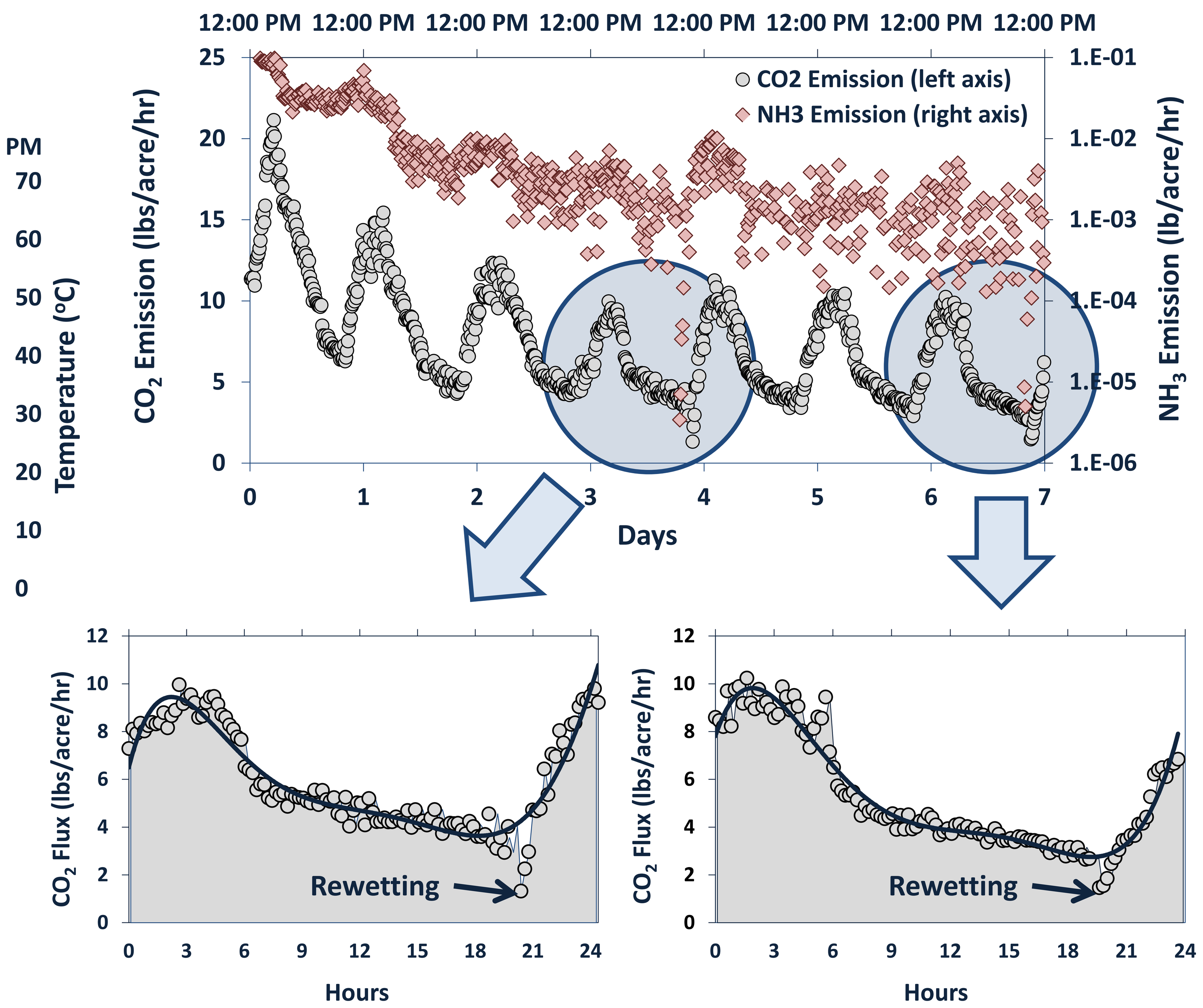


Results and Discussion

A. GS3 Sensor Outputs (Volumetric Water Content and Temperature)



B. Gas Emissions (CO_2 & NH_3)



Drying and rewetting events are important short-term natural phenomenon in terms of hydrological cycling within the soil-atmosphere system. We observed gas emissions of CO_2 (illustrated in Figures B) are influenced substantially by these events. During drying, a strong correlation was seen between gaseous emissions and temperature and moisture content.

Gas emissions were suppressed during and shortly after the rewetting process, mainly due to reduction in air- filled pore space causing reduced gas diffusivity in the upper soil layer. Emissions in response to rewetting events are critical for understanding of carbon and nitrogen dynamics and land-atmosphere gas exchange.

Acknowledgments

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