386

NO_X and CO Emissions from Cerrado Plant Litter

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Introduction

Previous field studies in pastures and native cerrado in central Brazil have indicated that surface plant litter and burn residues can be a major source of NO_X [nitric oxide (NO) plus nitrogen dioxide (NO_2)] and carbon monoxide (CO). Direct emissions of these gases from burning are a major global source. In addition, emissions of CO and NO_X from soils and plant litter also provide a significant source of the gases. Here we describe field and laboratory studies that provide more detailed information on factors that control these emissions.

Soil and litter temperatures, especially in open cerrado, are elevated compared to shaded surfaces. Solar irradiance is absorbed completely within the top cm of the surface and this results in rapid localized heating. Light can also induce photoreactions of surface organic matter and certain inorganic N species such as nitrite to produce CO and NO_X. One common technique for measuring trace gas fluxes involves the use of chambers sealed over the land surface. Usually, opaque chambers have been used for flux measurements, but we have used transparent chambers to learn more about the effects of natural warming and irradiation on the gas fluxes.

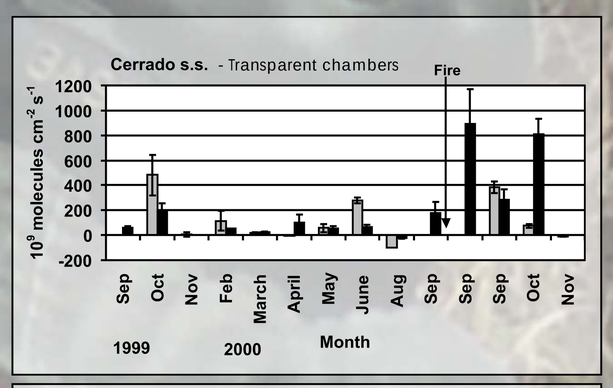
Methods

Gases were measured using transparent & opaque soil chambers (Figure 1). CO was measured monthly using both types of chambers. Samples were taken in syringes and analyzed in the lab using a Trace A gas chromatograph. NO_X was also measured with both chambers at selected field sites. A dynamic system in line with a Scintrex chemiluminescence NO_X detector was used.

A lab study used a temperature-controlled chamber and a solar simulator to attempt to separate the effects of light and temperature on NO_X emissions (Figure 2). Litter samples used in the laboratory studies were obtained from two native vegetation types in central Brazil, *cerrado stricto sensu* (20-50% canopy cover) and *campo sujo* (open scrubland) and from pastures (*Brachiaria brizantha* litter) located at an experimental farm near EMBRAPA Cerrados and at a cattle ranch (Fazenda Rio de Janeiro) that was 110 km north of Brasília.

Figure 1. *NO_X measurements with clear and opaque chambers in the field*

Figure 2. *Apparatus used to investigate effects of light and temperature on plant litter production of NO_X*



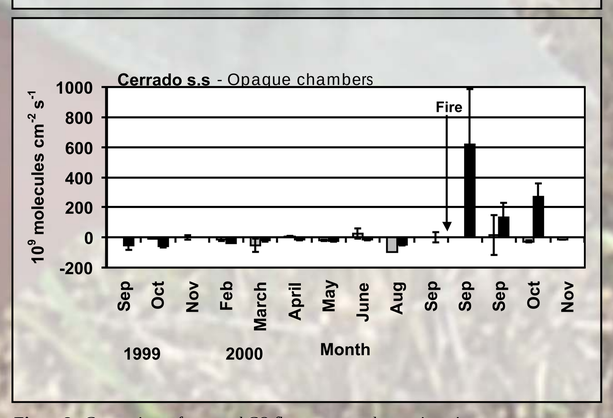


Figure 3. *Comparison of seasonal CO fluxes at cerrado s.s. site using transparent vs. opaque chambers*

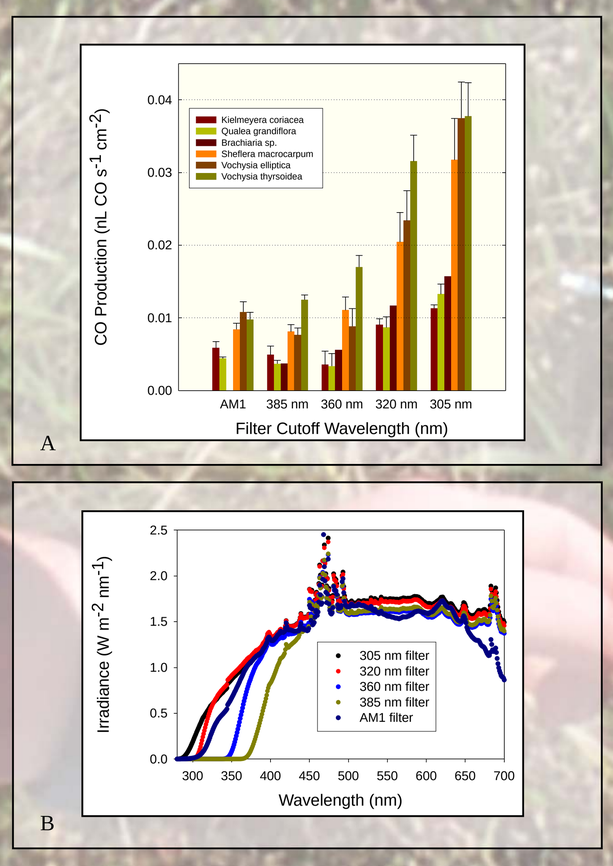
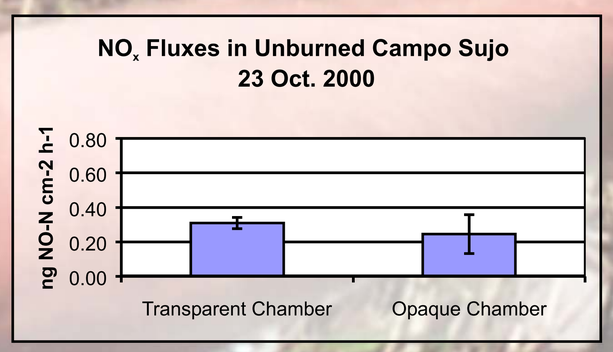
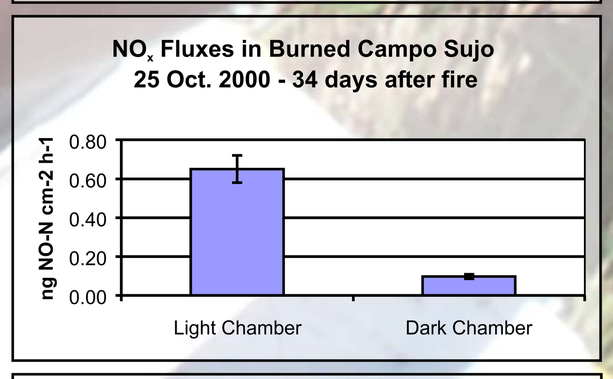
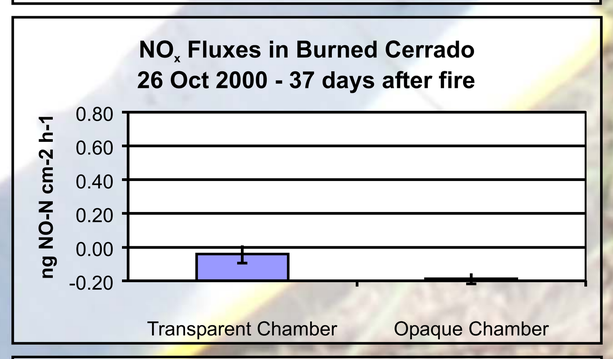


Figure 4. *Laboratory experiments on the effects of radiation wavelength on production of CO from Cerrado plant litter. A) Comparison of CO production rates with various wavelengths of the UV irradiance blocked using glass filters. Because UV radiation makes little contribution to surface heating, litter surfaces experienced almost the same warming in all these experiments. B) Spectral irradiance of light source with various cutoff light filters.*







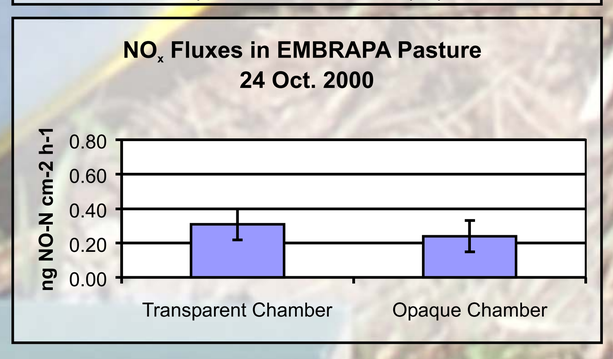


Figure 5. *Comparison of NO_X fluxes in transparent and opaque chambers. The measurements were made at native unburned and burned Cerrado sites and at a 20-year old cattle pasture. Methods are illustrated in Figure 1.*

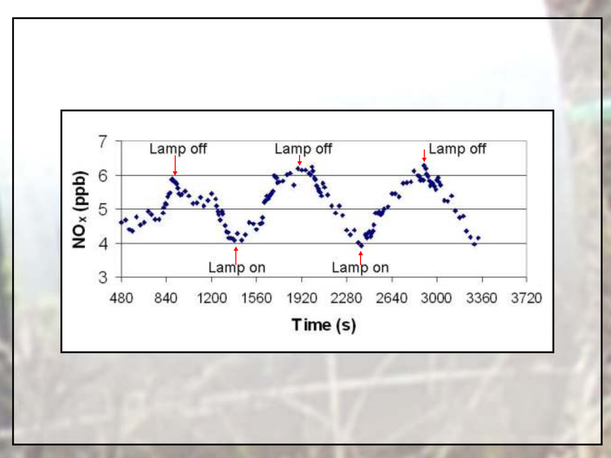


Figure 6. *Effects of irradiation in a solar simulator on production of NO_X from grass litter. Other results showed that the grass litter was warmed by 15 – 20°C when the lamp was on.*

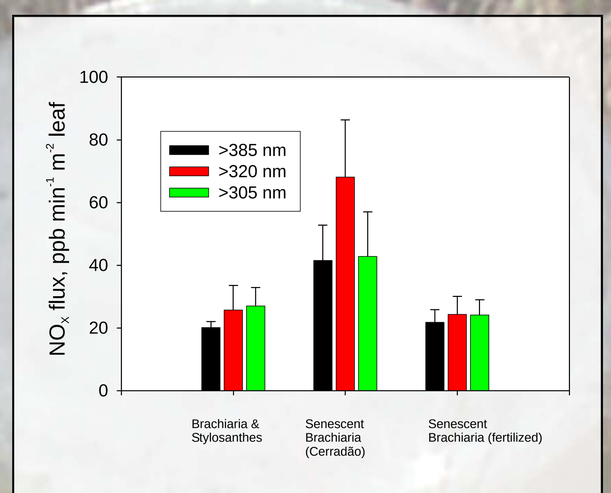


Figure 7. *Laboratory experiments on the effects of radiation wavelength on production of NO_X from Cerrado plant litter. The results indicate that UV exclusion has minimal effects on the fluxes and thus that the observed enhancement is due mainly to temperature effects on microbial or thermal processes.*

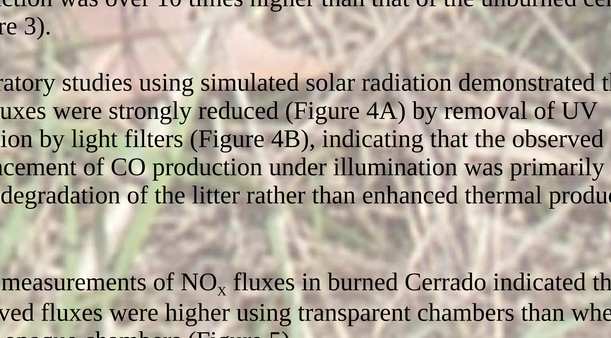


Figure 8. *Photoproduction of NO_X from burned (ash) and unburned Brachiaria litter under irradiation by a solar simulator. The UV-A irradiance was adjusted to match that observed at Cerrado sites during midday September (3.35 mW cm^{-2})*

Results

CO

Field studies showed that daytime fluxes of CO in the transparent chambers were always higher than in the opaque chambers (Figure 3). Similarly, a diurnal study showed negative fluxes for all nighttime measurements and positive measurements for all daytime measurements. Fire increased soil surface CO emissions significantly in the burned cerrado plot. Thirty days after the fire, daytime CO production was over 10 times higher than that of the unburned cerrado (Figure 3).

Laboratory studies using simulated solar radiation demonstrated that CO fluxes were strongly reduced (Figure 4A) by removal of UV radiation by light filters (Figure 4B), indicating that the observed enhancement of CO production under illumination was primarily due to photodegradation of the litter rather than enhanced thermal production.

NO_X

Field measurements of NO_X fluxes in burned Cerrado indicated that the observed fluxes were higher using transparent chambers than when using opaque chambers (Figure 5).

Laboratory experiments showed that NO_X emissions from grass litter were stimulated with exposure to simulated solar radiation (Figure 6). Wavelength studies indicated that exclusion of the UV component of the irradiance had little effect on the NO_X fluxes (Figure 7). This result suggests that the effect is mainly driven by solar warming of the litter. Other studies showed that NO_X fluxes from burned grass litter residues were considerably higher than from unburned senescent grass litter (Figure 8).

Conclusions

This study supports other findings in different biomes that photodegradation of organic matter, especially with UV radiation, enhances CO emissions.

Light exposure also can enhance NO_X emissions from soils and litter with the largest effect observed with burned surfaces. This work suggests that fire creates precursors to CO and to NO_X that are thermally and/or photochemically reactive.

The results indicate that NO_X and CO flux measurements with opaque chambers can underestimate the emissions of these gases, especially in open, recently burned sites.

Disclaimer: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.