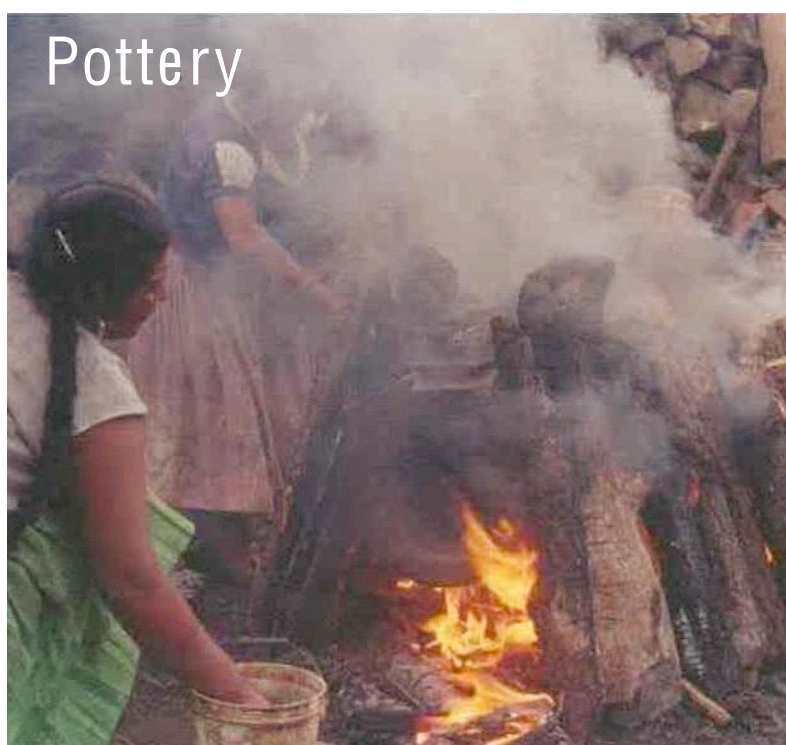


Co-benefits from mitigation of emissions and aerosol toxicity from small-scale industries in Mexico

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Introduction

- Combustion devices used for small-scale industries in developing regions generally have high emission factors for short lived greenhouse species including CH₄, CO and carbonaceous aerosols due to relatively low combustion temperatures and inefficient technology, leading to substantial regional contributions.
- Of critical importance is black carbon, which is reported to be second only to carbon dioxide in its magnitude as a global warming species¹. Since black carbon's atmospheric lifetime is only days or weeks, actions taken today will have almost immediate benefits in slowing global warming while future low carbon and carbon free technologies are developed.
- Emission factors for small-scale industries are largely unknown in Mexico, and application of industrialized country emission factors, such as those from the USEPA's AP-42 database would almost certainly result in considerable errors in climate and pollution transport models.
- Little information is available on the toxicity of aerosol emissions from these industries, although transition metals in aerosol emissions have been related to severe airway inflammation, airway hyperreactivity, and mortality^{2,3}.



Pottery



Mezcal

Objective

- This study combines measurements of emissions of short lived global warming species with in vitro assessment of oxidative stress in lung macrophage cells from small-scale industries in rural Mexico to characterize the global warming emissions and environmental health burden that these industries pose to local communities.

References: 1. Ramanathan, V.; Carmichael, G., Global and regional climate changes due to black carbon. *Nat Geosci* 2008, 1, (4), 221-227.
2. Dreher, K. L.; Jaskot, R. H.; et al. Soluble transition metals mediate residual oil fly ash induced acute lung injury. *J Toxicol Env Health* 1997, 50, (3), 285-305.
3. Pritchard, R. J.; Ghio, A. J.; et al. Oxidant generation and lung injury after particulate air pollutant exposure increase with the concentrations of associated metals. *Inhal Toxicol* 1996, 8, (5), 457-477.
4. Johnson, M.; Edwards, R.; et al. In-field greenhouse gas emissions from cookstoves in rural Mexican households. *Atmos Environ* 2008, 42, (6), 1206-1222.

Small Industries in the Meseta Purépecha



Brick



Charcoal

Brick making kilns (see photos)

- Workers constantly tend the kiln, firing 5-20,000 bricks over a 1-3 day period. Preliminary estimates are that it constitutes 22% of regional biomass fuel consumption.

Pottery making

- Making of traditional pottery takes 8-12 hours in kilns, preliminary estimates are that uses 15% of regional biomass fuel consumption.

Charcoal making

- Requires constant tending of the kiln over a period of 5-12 days. Preliminary estimates of 12-15% of regional biomass fuel consumption.

Distilling Mezcal

- Distilling mezcal, a spirit made from agave, requires long periods of low temperature combustion. Initial cooking of the Agave is done over 4 days and the distillation process takes a further 2-4 days in traditional alambiques. Preliminary estimates of 2-3% of regional biomass fuel consumption.

Copper making

- Making of copper art and goods uses a charcoal furnace over a period of 2-3 hours, using <1% of regional biomass fuel consumption.

Emissions Measurement

The full scale field project is currently underway in Mexico collecting gaseous emission samples over the full burn cycle from each kiln type into metal lined multilayer gas bags for subsequent analysis of CO₂, CH₄, CO and total non-methane hydrocarbons using gas chromatography. Aerosol emissions are collected on pre-fired quartz filters to be analyzed by thermal-optical technique for organic and elemental carbon, and for in vitro toxicity tests. Finally more refined fuel consumption estimates are also being undertaken.

Preliminary Results

- Figure 1 shows minute-by-minute CO₂/(CO₂+CO) ratios as a proxy for nominal combustion efficiency for a typical traditional brick kiln in Michoacán, Mexico.
- The low mean combustion efficiency of 85% (see dashed line in figure 1) indicates that 15% of combusted carbon is being emitted as methane, black carbon, and other products of incomplete combustion.

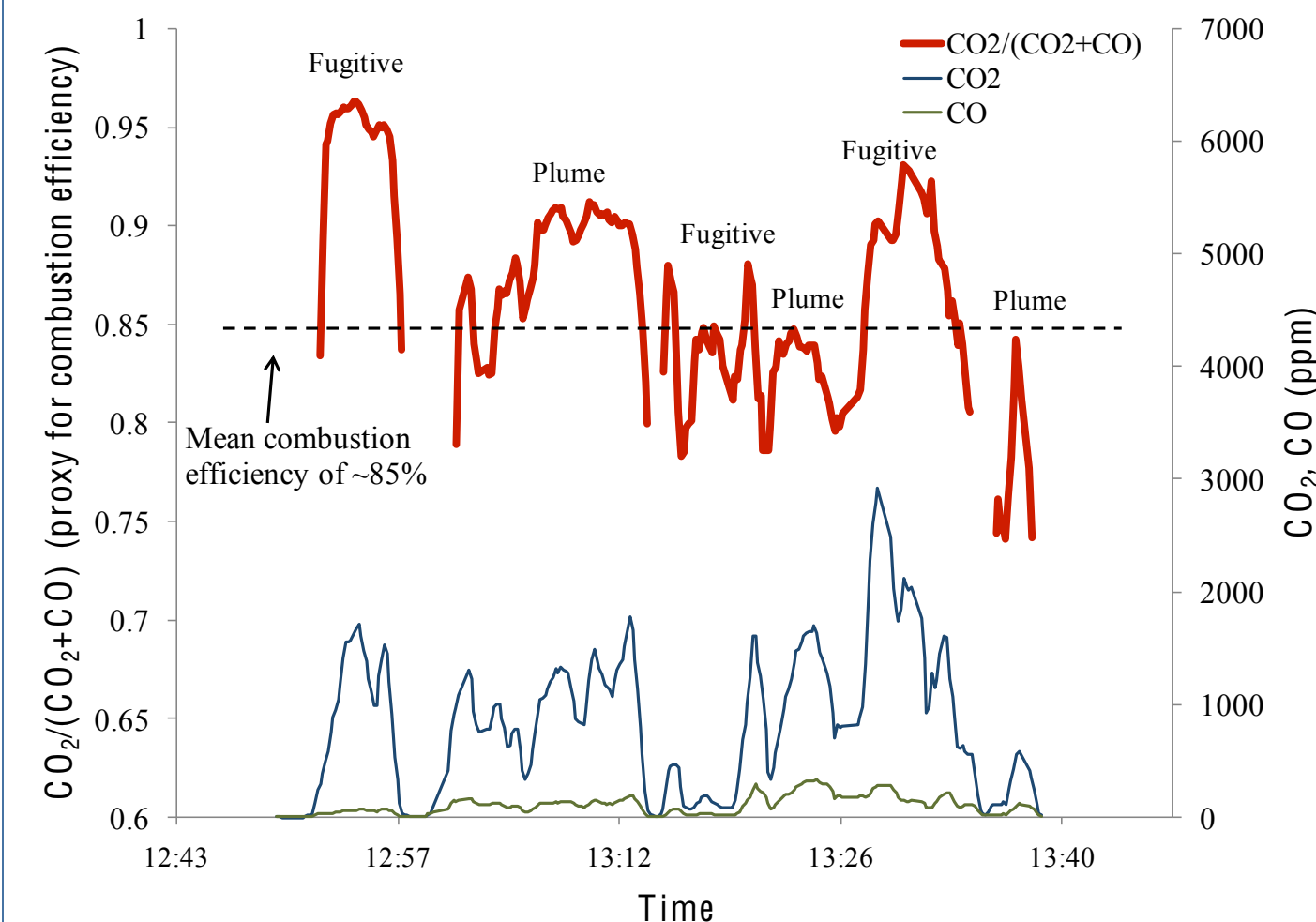


Figure 1: Minute-by-minute CO₂/(CO₂+CO) ratios as a proxy for combustion efficiency for a typical traditional brick kiln in Michoacán, Mexico.

- Using emission ratios of short lived gaseous species relative to CO₂/(CO₂+CO) ratios for wood combustion in the region⁴, and regional fuel consumption estimates, these preliminary data suggest that small-scale industries could be responsible for up to 50% of regional CH₄ and black carbon emissions from biomass energy use.
- Considerable potential exists for reducing emissions from this sector with better technology as even a modest 7-8% increase in combustion efficiency would result in reducing productions of incomplete combustion such as methane and black carbon by 50%.
- Since particulate black carbon has been related to adverse health impacts from air pollution, considerable co-benefits would be possible through modest improvements to combustion efficiency.

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