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Trace gas and particle emissions from domestic and industrial biofuel use and garbage burning in central Mexico

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Abstract. In central Mexico during the spring of 2007 we measured the initial emissions of 12 gases and the aerosol speciation for elemental and organic carbon (EC, OC), anhydrosugars, Cl^-, NO_3^-, and 20 metals from 10 cooking fires, four garbage fires, three brick making kilns, three charcoal making kilns, and two crop residue fires. Global biofuel use has been estimated at over 2600 Tg/y. With several simple case studies we show that cooking fires can be a major, or the major, source of several gases and fine particles in developing countries. Insulated cook stoves with chimneys were earlier shown to reduce indoor air pollution and the fuel use per cooking task. We confirm that they also reduce the emissions of VOC pollutants per mass of fuel burned by about half. We did not detect HCN emissions from cooking fires in Mexico or Africa. Thus, if regional source attribution is based on HCN emissions typical for other types of biomass burning (BB), then biofuel use and total BB will be underestimated in much of the developing world. This is also significant because cooking fires are not detected from space. We estimate that ~2000 Tg/y of garbage are generated globally and about half may be burned, making this a commonly overlooked major global source of emissions. We estimate a fine particle emission factor ($EFPM_{2.5}$) for garbage burning of ~10.5±8.8 g/kg, which is in reasonable agreement with very limited previous work. We observe large HCl emission factors in the range 2–10 g/kg. Consideration of the Cl content of the global waste stream suggests that garbage burning may generate as much as 6–9 Tg/yr of HCl, which would make it a major source of this compound. HCl generated by garbage burning in dry environments may have a relatively greater atmospheric impact than HCl generated in humid areas. Garbage burning $PM_{2.5}$ was found to contain levoglucosan and K in concentrations similar to those for biomass burning, so it could be a source of interference in some areas when using these tracers to estimate BB. Galactosan was the anhydrosugar most closely correlated with BB in this study. Fine particle antimony (Sb) shows initial promise as a garbage burning tracer and suggests that this source could contribute a significant amount of the

$PM_{2.5}$ in the Mexico City metropolitan area. The fuel consumption and emissions due to industrial biofuel use are difficult to characterize regionally. This is partly because of the diverse range of fuels used and the very small profit margins of typical micro-enterprises. Brick making kilns produced low total $EFPM_{2.5}$ (~1.6 g/kg), but very high EC/OC ratios (6.72). Previous literature on brick kilns is scarce but does document some severe local impacts. Coupling data from Mexico, Brazil, and Zambia, we find that charcoal making kilns can exhibit an 8-fold increase in VOC/CO over their approximately one-week lifetime. Acetic acid emission factors for charcoal kilns were much higher in Mexico than elsewhere. Our dirt charcoal kiln $EFPM_{2.5}$ emission factor was ~1.1 g/kg, which is lower than previous recommendations intended for all types of kilns. We speculate that some $PM_{2.5}$ is scavenged in the walls of dirt kilns.

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