An accurate, real-time and low-cost method to measure biomass smoke

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Background

In the developing world, approximately 3 billion people cook their food by burning solid fuels with the majority using biomass in polluting and inefficient rudimentary stoves. This number is expected to increase in the coming decades. This use of biomass fuels represents a significant part of energy use in developing regions. The products of incomplete combustion from biomass cookstoves include methane, ozone-precursors, organic carbon and black carbon (BC), which are important greenhouse pollutants. Emissions from cookstove use also have been linked to adverse respiratory, cardiovascular, neonatal, and cancer outcomes. Exposure to cookstove emissions leads to an estimated 4 million deaths each year. Given the substantial threat to public health particularly for women and children, and the uncertainty about the climate effect resulting from cookstove use in developing countries, further study is needed to pinpoint the most beneficial strategies for reducing emissions from this source.

Problem

Mitigating emissions from biomass cookstoves depends first on identifying technologies that are proven effective in reducing emissions, and second on disseminating these technologies on a large scale. Currently, a wide range of improved stove technologies is available including Berkeley Darfur Stoves (BDS), electric stoves, advanced biomass stoves, rocket stoves, solar cooker, etc, but the potential climate and health benefits vary substantially by technology and fuel options. The ability to accurately characterize cookstove emissions in the laboratory and in the field is essential but currently very weak.

Solution

Automated on-line measurements can quantify emission reductions and exposure under actual operating conditions. Prior work has shown that organic components in biomass smoke particles absorb light at 370 nm more effectively than 880 nm in two-wavelength aethalometer (Magee Scientific, Berkeley, CA) measurements. This enhanced absorption (Delta-C = BC370nm – BC880nm) can serve as an indicator of biomass combustion emissions. A strong linear relationship between Delta-C and levoglucosan (a classic biomass combustion marker) was recently observed in Rochester, NY during the winter heating season (Wang et al., 2011). Compared to filter-based levoglucosan measurement, this aethalometer method is simpler, cheaper, more readily accessible, and has higher time resolution for indicating the contributions of biomass smoke to ambient or indoor pollution. In our study, this method will be tested using the BDS under laboratory controlled cooking conditions – water boiling tests (WBT, version 4, http://www.pciaonline.org/node/1048).

Implication

The discrepancies between laboratory and field testing have hindered previous cookstoves development efforts. Improved laboratory studies and testing protocols that can recreate field conditions are needed. This discrepancy suggests a need to undertake further validation of the Delta-C method for different biomass fuels (e.g. waste, charcoal, animal dung, twigs) over a range of burning conditions. Once validated broadly, the Delta-C method would make it easier and cheaper to accurately quantify the cookstove emission levels in the field.

Standardized tests using aethalometer Delta-C measurement performed for the variety of fuels, field conditions, and cooking practices could help determine which stoves are most successful in the field for improving fuel efficiency, emissions, and health, and shed light on the persistent discrepancy in measured emissions in the field versus in the laboratory.

References

Wang, Y., Hopke, P. K., Rattigan, O. V., Xia, X. (2011) *Environ. Sci. Technol*. **45** (17), 7387-7393.