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Project Summary

Greenhouse Gases from Small-scale Combustion in Developing Countries – A Pilot Study in Manila

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This report presents the results of a pilot study in Manila, Republic of the Philippines, to evaluate the emission potential of greenhouse gases (GGs) from small-scale combustion devices used for cooking in most of the world's households. The results from the pilot study suggest that this may represent a more significant source than previously thought. As a result, it has been decided to conduct a more comprehensive study in India and China. The results from this work will be used in EPA's Global Climate Change Program to develop a more reliable estimate of the GG potential of the fuel types and types of small-scale combustion devices being used in most of the world's households.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

It is clear that the combustion of biomass plays a significant role in global atmospheric chemistry and thus in the potential for global warming from an enhanced GG effect. As shown in Table 1, for example, three recent reviews estimate the contributions of biomass combustion to global emissions to be as high as 20 - 50% for some of the major GGs. From biomass combustion, much of the carbon dioxide (CO_2) does not result in a net increase in atmospheric concentration because the gas is also taken up by terrestrial biomass and soil. Although the other GGs are also taken up to some extent, more of the releases from biomass combustion may result in net atmospheric additions. In addition, the uncertainty in our knowledge is substantially larger for the non-CO_2 GGs than for CO_2.

Estimates

Although uncertain, the contribution of biomass combustion to the global carbon cycle has been estimated in five categories. These are reorganized and expanded in Table 2 along with estimated total carbon emissions. Four categories represent processes of large-scale open combustion, i.e., outdoor fires associated with swidden agriculture, permanent deforestation, savannas, and crop residues. Much crop residue is also burned in small-scale closed or semi-enclosed conditions in cooking and heating stoves. As shown, estimated crop residues used in stoves are about 350 million tonnes. In addition, most firewood in the developing world is burned in semi-enclosed conditions or made into charcoal for use under such conditions. Thus, the developing-country biomass fuel flow (crop residues, fuelwood, and wood for charcoal) represents much of the total global carbon emissions from all biomass combustion, more than 20%, and perhaps approaching 50% (based on Table 2).

In recent years, the wide uncertainty about emissions from open large-scale bio-

Table 1. *Estimates of Global GG Emissions from Biomass Burning (Tg/yr, element basis) (1)**

	Biomass	Total	% Biomass(2)	% Biomass(3)	% Biomass(4)
CO_2	3500	8700	40	25-45%	
CO	350	1100	32	15-50%	
CH_4	38	380	10 (5)	3-10%	8%
N_2O(3)	0.1-0.3	12-14	—	0.8-2%	0.4-2%
TNMOC**	24	100	24		
CH_3Cl	0.51	2.3	22		

* *Data from source (1) unless otherwise noted by numbers in parentheses. All sources are identified in the full report.*

** *Total non-methane organic compounds (including, but not limited to, NMHC; i.e., non-methane hydrocarbons).*

Table 2. *Total Carbon Released by Biomass Combustion*

	Tg/yr
*Open Burning (1)**	
Swidden Agriculture	500-1000
Permanent Deforestation	200-700
Savanna Fires	300-1600
Crop Residues	150-450
Enclosed Burning in Developing Countries (2)	
*Crop Residues***	350
Firewood	540
Wood for Charcoal	70
Wood in developed countries (3)	80
Total Biomass	2100-4700
Total Fossil Fuels	5700

* *Sources, indicated by numbers in parentheses, are identified in the full report.*

** *Includes animal dung used as fuel.*

mass fires, has led to a substantial increase in attention given to measuring and understanding these processes. Substantially less attention, however, has been given to two categories, firewood and crop residues in small-scale combustion devices.

In both categories, the uncertainty about total emissions is partly due to uncertainty in the source terms (i.e., how much is burned each year) and partly to uncertainty in the emission factors (i.e., how much of each GG is emitted per kilogram burned). In general, emissions factor estimates are based on a rather small set of measurements made in field and laboratory situations. Most of these have been designed to duplicate the conditions of open large-scale combustion. As a result, emissions from fuelwood are rated in category D in certainty, where A is most certain and E is least certain.

This is unfortunate, for it is clear that emission factors for biomass are quite sensitive to changes in combustion conditions. It should not be assumed, therefore, that emission factors derived for open large-scale combustion can be appropriately applied to small-scale semi- or completely enclosed combustion. Yet it seems that perhaps 90% of the firewood and a large fraction of the combusted crop residues in the world (Table 2) are burned under such conditions in household cooking and heating stoves. Although household heating stoves are an important factor in total wood combustion in developed countries, the vast majority are used for cooking and space heating in developing countries. Globally, something like 50% of the households in the world use simple biomass fuels (wood, charcoal, crop residues, animal dung) for cooking.

Conclusions

More extensive field measurements of GG emission factors for a range of fuels and combustion devices would be useful in pinning down global GG emissions inventories that are now known within rather wide ranges of uncertainty. In addition, they would help in the design of GG-reduction strategies, for it is possible that changes in fuel and/or combustion conditions in these small devices may be a cost-effective way to address part of the GG problem on a global basis.

To some observers, it might seem more appropriate to monitor GG emissions from such stoves in controlled settings, as is done with other combustion devices, such as gas stoves and automobiles. Unfortunately, experience has shown that, because slight changes in combustion conditions in small stoves (e.g., in the fire-tending behavior of the cook) can have large impacts on emissions factors, it is difficult to know whether laboratory or simulated conditions actually duplicate those in the field sufficiently well to be relied upon. A better database of field measurements will be a necessary step in eventually designing reliable laboratory measurement techniques.

Since little is also known about emission factors from small-scale combustion of other fuels in developing countries, it would be valuable to test them as well. Kerosene and liquefied petroleum gas (LPG), for example, are often the fuels that first substitute for biomass as development occurs in developing countries. Consequently, their emission levels provide a reasonable interim target for what might be achieved by a program to reduce biofuel use in households.

A large-scale field monitoring effort for GG emission factors in developing countries would entail significant costs and uncertainties. In this situation, it seemed appropriate to undertake a pilot study in advance.

Thus, to examine the feasibility of a larger study to improve knowledge of GG emission factors for small-scale biofuel combustion, a pilot study was conducted in Manila beginning in September 1990.

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The complete report, entitled "Greenhouse Gases from Small-scale Combustion in Developing Countries –A Pilot Study in Manila," (Order No. PB92-139 369/AS; Cost: $19.00; subject to change) will be available only from:

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