Carbon emission factors from wood combustion of improved cook stoves

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Particulate matter (PM) is considered one of the most important parameters in air pollution. PM generated from burning biomass shows significant toxicity and carcinogenic potentials besides to be an important source of black carbon (BC) and greenhouse gases (GHGs). BC is considered a short live climate forcer (SLCF). Cocking stoves that use biomass as fuel are considered important sources of BC. A quarter of the population in Mexico lives in rural areas and uses traditional cocking stoves. However, the size of the problem in Mexico is uncertain because the emission factors used to estimate SLCF inventories have a large uncertainty.

We present the results of an experimental study to estimate preliminary emission factors of $PM_{2.5}$, organic carbon (OC) and black carbon (as elemental carbon, EC) from the burning of oak wood in three improved biomass cooking stoves (Onil, Patsari and Ecoestufa) and one 3-stone stove using the water boiling test (WBT). We used a dilution chamber for the sampling of the PM and the measurement of combustion gases from exhaust products emitted by the cookstoves. The WBT consists of three consecutive tests: cold start, hot start, and a 45-min simmer period. The WBT is a simplified simulation of the cooking process.

The sampling of PM was performed at one sampling port located at the end of the dilution chamber through a $PM_{2.5}$ cyclone connected to a filter support and a vacuum pump. The material collected in the filters consisted of integrated PM samples for each of the stages of the WBT. The analysis of carbon in the collected PM was carried out with an UIC analyzer CM5014. In addition, continuous measurement of combustion gases and other particle parameters was performed with an instrumented mobile lab connected to another sampling port of the chamber.

The OC and EC emission factors were obtained by dividing the mass of PM, OC and EC per kilogram of dry wood burned. We assumed that most of the carbon contained in the wood was converted to CO and CO_2, and that the remaining carbon was transformed into other species such as carbonaceous aerosols. We used the carbon balance approach to determine the carbon fraction in the wood and the combustion gases emission factors.

The 3-stone showed the highest $PM_{2.5}$ emission factor (5.53 g/kg wood burned) and the highest EC emission factor (0.74 g/kg wood burned) (Figure 1). The 3-stone EC emission factor was around 9 times higher than the estimated EC emission factors for the Onil and Patsari stoves (0.07 y 0.08 g EC/kg wood burned, respectively). The Ecoestufa also showed a high EC emission factor (0.36 g EC/kg wood burned).

It is hypothesized that the highest PM emissions occurred during the hot start stage, while the lowest in the simmer stage of the same WBT. This difference in the PM emissions could be explained following the theoretical advance of the combustion process as the wood is burned, as is proposed below.

At the start of each stage, a strong flaming process leads to the production of darkened particles. As the combustion proceeds, it stabilizes and flames are smaller leading to a lesser generation of darkened particles and condensed organic aerosols. These patterns of the combustion process were inferred from the time series data of the PM absorption coefficient and the scattering coefficient, and the CO_2 and CO concentrations during each stage. The observed lower PM emission in the simmer stage possibly was due to the slow and stable combustion conditions.

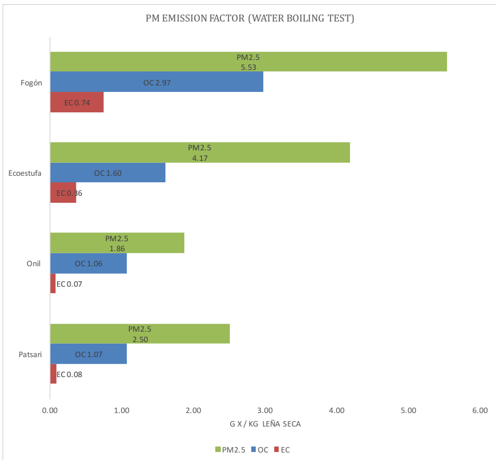

Figure 1. $PM_{2.5}$, EC and OC WBT emission factors of cookstoves and three stone.

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Consulted references:

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