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LABORATORY ESTIMATION OF BLACK CARBON EMISSIONS FROM COOKSTOVES

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Recent estimations show that residential solid fuel combustion accounts for 25% of global black carbon (BC) emissions (Lamarque et al., 2010). Thus, the control of these emissions through the implementation of cleaner cooking technologies could be crucial for climate change mitigation (Venkataraman et al., 2005). However, BC emission factors for biofuel cooking stoves have been poorly estimated due to the wide distribution and remote location of the stoves and the relatively complex existing assessment methods.

This work presents results on BC emission factors (EF) estimation from combustion of biomass cooking systems in Western Africa (in Senegal). Three stones fire (traditional stove), Noflaye Jegg (rocket stove), Jambaar bois (ceramic improved stove) and a gasifier were analysed under laboratory conditions at the Centre de Recherche sur les Energies Renouvelables (CERER) in Dakar. Two types of fuels (wood species) were tested: Casuarina Equisetifolia (Filao) and Cordyla Pinnata (Dimb). Three replicates of the standardized Water Boiling Test with two phases (cold start and simmer) were conducted at the laboratory to test each cooking system. $PM_{2.5}$ emissions were collected on quartz fibre filters, and BC content was subsequently analysed using three analytical methods: i) Nexleaf system, in which a photograph of the filter is compared with a calibrated reference scale; ii) the EEL43 Smoke Stain Reflectometer; and iii) the Sunset Laboratory OCEC Analyzer. The two first were compared with the third one, considered the internal reference.

Linear regression of BC data from the Nexleaf system versus EC from the Sunset OCEC analyser shows a relative good agreement between both methods. By regressing the reflectance values (RR) against the EC load ($\mu g/cm^2$) an equation was obtained to calculate the EC content on the filters using the reflectometer. Figure 1 shows the variation of BC EF due to the type of stove, type of wood and WBT phase. In the case of the gasifier, only the average EF of the entire WBT was calculated because it has a cylindrical combustion chamber that cannot be emptied during the burning cycle.

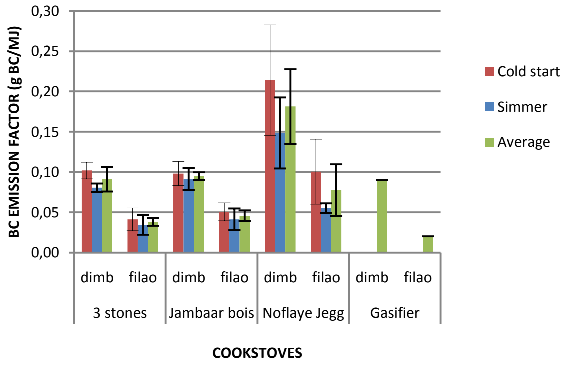

Fig.1. BC EF variation per WBT phase

BC emissions during the cold start phase were higher for every type of stove. During this phase emissions are usually very high, while the simmer phase is characterized by smaller flames with lower BC emissions. The BC EF from burning dimb was higher than using filao in all the stoves, despite the fact that both species had similar moisture fraction (8% and 8,8%) and calorific value (21,79 MJ/Kg and 19,0 MJ/Kg). This confirms that wood species are important factors influencing BC emissions. The type of stove also shows a significant effect on the BC EF, which is related to the nature of combustion. I.e., the rocket and ceramic improved stoves have a stronger draft and higher temperature flames, creating more warming particles. The three-stone fire produces a larger bed of charcoal under the flaming fuel and the gasifier stove creates little flame but more charcoal, producing lower BC emissions. Field studies need to be conducted to quantify BC emissions taking into account actual cooking practices. Moreover, analysis of organic carbon and total particulate matter emissions should be included to be able to estimate the net climate effect of each cooking system.

References

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