An improved metric for biomass burning: novel semi-online experimental apparatus

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Particulate matter emissions from biomass burning have a big impact on both climate and public health. According to the world health organization, alone the pollution from cooking with solid fuels causes yearly millions of premature deaths. Despite this, only few countries have a thorough legislation that limits biomass burning emissions. The European Union is working towards a generalized legislation that will impose emission limits for biomass burning appliances to all member countries. This calls for a careful discussion about an appropriate metric, as legislation can only be as good as the technique used to characterize the emissions. Current legislation is not ideal for several reasons. A big problem is that standards for particulate matter emissions (PME) are based on total mass without differentiation by chemical composition or particle size.

We will discuss an approach that aims to complement PME standards. Current measurements are based on gravimetric sampling, which underestimates the contribution of particle bound organic carbon (OC) and pays no attention to the potential for secondary aerosol (SOA) formation. Source apportionment studies establish OC and in particular SOA as the largest carbonaceous fraction of biomass burning emissions (Lanz et al., 2007). This makes biomass burning SOA one of the most important atmospheric pollutants in Europe (Denier van der Gon et al., 2015).

Our proposed method is two-stepped. First, the emissions are aged by means of the micro smog chamber (MSC; Keller and Burtscher, 2012). Aging incorporates the potential for SOA formation to the measured PME. This would otherwise be difficult to establish as parameters like, e.g., organic gaseous carbon (OGC), NOx, CO or PME are only poorly linked to SOA. As a matter of fact, our results show that only a small fraction of the OGC is responsible for most of the SOA formation.

The quantification of the emissions is done through a total carbon (TC) analysis of particle bound carbon. This fraction of the emissions is a good indicator of the quality of the combustion, has been linked to a much higher toxicity than non-carbonaceous material (Lelieveld et al., 2015; Sigsgaard et al., 2015), and is easier to perform than a split analysis of particle bound organic carbon (OC) and elemental carbon (EC).

Our prototype is designed to work semi-online. A sample is captured on a filter which is afterwards heated rapidly within the sampling unit to burn the carbonaceous content under an oxidizing atmosphere. Total carbon detection is done by means of a CO_2 measurement. Fast heating shortens the analysis time, 1 to 2 minutes depending on loading conditions (see, e.g., figure 1), and results on a better limit of detection. At the same time, our goal is to keep the cooling down as short as possible to allow for a new sampling cycle within a few minutes.

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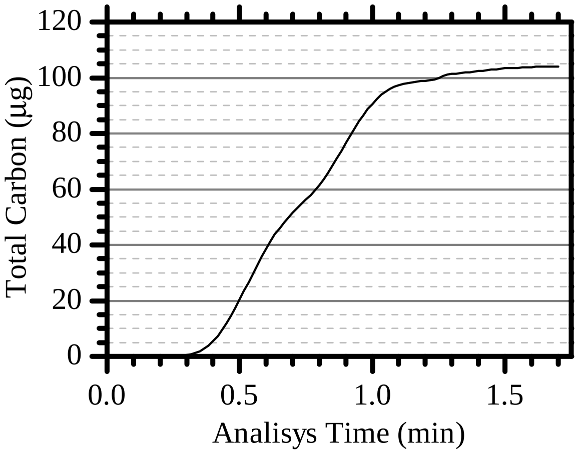

Figure 1: Example of a total carbon measurement cycle performed using our analysis system. The curve shows the cumulative integral of particle bound carbon form a CAST aerosol sample (Jing ltd, Switzerland) as calculated from the CO_2 measurement. In this example, the analysis was performed using ambient air as a carrier gas. Time zero marks the start of the filter heating. The analysis was over after 60 seconds of heating and 90 seconds of CO_2 measurement.

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