Sugar markers in biomass burning particles from a Brazilian agro-industrial region

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The State of São Paulo (SP) alone accounts for over 50% of the total area (96,166 km^2) used for sugar cane plantations in Brazil. Burning of the sugar cane foliage before harvesting still occurs in about 40% of the cultivated land in SP, and there is not an official program to phase out burning in other States. Consequently, large amounts of gases and aerosol are released into the atmosphere during the harvest period (April – November) each year. In addition to human health effects, these emissions potentially affect cloud formation, precipitation, and radiative fluxes.

In this study, sugar markers in total aerosol samples from highly impacted agro-industrial regions (Araraquara and Ourinhos - SP) were used to improve understanding of the contribution of smoke particles from sugar cane burning to the chemical composition of the lower troposphere. We also intend to discuss other markers (K^+, Ca^{2+}, Soluble Organic Carbon, PAHs) and solubility properties of the aerosol.

Aerosol samples (n = 112) were collected using a high-volume sampler fitted with glass fiber filters. Sugars were extracted with dichloromethane /methanol, and sugar speciation was conducted for seven samples (Alves *et al*., 2011).

Levoglucosan (L) was the anhydrosugar that most contributed to the aerosol mass. Concentrations were in the ranges (i) 25 - 1406 ng m^{-3} at night, (ii) 50 - 397 ng m^{-3} during the daytime, and (iii) 12 - 382 ng m^{-3} for 24-h averages. The latter range was similar to those obtained for other locations where there is intense sugar cane production (Urban *et al*., 2012; Souza, 2011). Concentrations of mannosan (M) (2.40 - 274 ng m^{-3}) and galactosan (G) (1.81 - 274 ng m^{-3}) were about 10 times lower than levoglucosan at all times. Since burning operations were normally conducted in the evening and during the sugar cane harvest period, there were distinct diurnal and seasonal trends that were similar for the three anhydrosugars (Figure 1).

Although the majority of fires occurred during the dry season, it was still possible to detect and quantify several biomass burning markers during the wet season (November–February; non-harvest period). This could be due to the use of fire for land clearance (rural and urban fires) and to the combustion of sugar cane bagasse (the crushed solid cane residue), which returns to the production process as an energy source or is used to generate electricity.

In addition to anhydrosugars, 17 other sugars were quantified. Four of these (erythrose, maltose, arabinose, and ribose) showed behavior similar to that of levoglucosan. Overall L/M and L/G ratios were 8.64 ± 5.70 (n = 109) and 12.1 ± 7.93 (n = 109), respectively. These values are similar to those obtained for controlled sugar cane burning (Hall *et al.*, 2012) and for other regions within the State of São Paulo (Vasconcellos *et al.*, 2010). The L/M ratios for the aerosols collected during the harvest period (9.54 ± 4.39) and the non-harvest wet season (7.60 ± 3.67) were not significantly different. An L/M ratio of 10.8 was obtained for aerosols collected near a fire on pasture with scrub, which is similar to that for sugar cane leaves. Aerosol from the Amazon region did not seem to affect the study region, given the much higher L/M ratios reported for Amazonia (ca. 20; Kundu *et al.*, 2010). Combustion of different types of wood from Europe and the USA resulted in L/M values that were mostly between 1 and 6 (Gonçalves *et al.*, 2011; Medeiros and Simoneit, 2008).

In conclusion, smoke particles were generated on a regional scale and were derived from agricultural practices. Burning of sugar cane leaves will be totally eliminated by the year 2017, which will result in a major shift in the trace component chemistry of the lower troposphere in rural areas of São Paulo State.

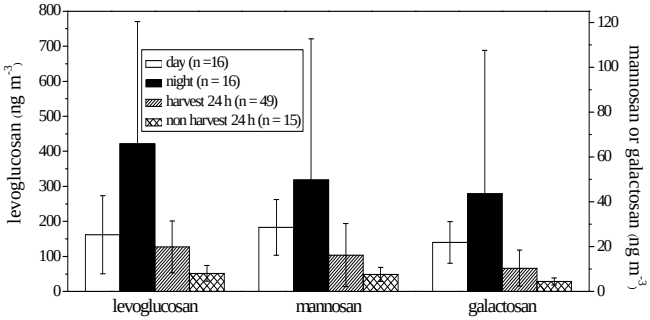

Figure 1: Average concentrations of monosaccharides during different periods.

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Alves, C. *et al*. (2011) *Sci. Tot. Environ*. **409**, 1466-75.
Gonçalves, C. *et al.* (2011) *Atmos. Environ.* **45**, 4533-45.
Hall, D. *et al.* (2012) *Atmos. Environ.* **55**, 164-172.
Kundu, S. *et al.* (2010) *Aerosol Sci.* **41**, 118-133.
Medeiros, P. M. and Simoneit, B. R. T. (2008) *Environ. Sci. Technol.* **42**, 8310-8316.
Souza, D. Z. (2011) *PhD Thesis. Universidade de São Paulo.*
Vasconcellos P. C. *et al.* (2010) *Environ. Sci. Technol.* **408**, 5836-5844.
Urban, R. C. *et al.* (2012) *Atmos. Environ.* **61**, 562-569.