GREENHOUSE GAS EMISSIONS FROM FIRE AND THEIR ENVIRONMENTAL EFFECT

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INTRODUCTION

Fire directly impacts the carbon balance of forests through emissions of carbon dioxide (CO_2), carbon monoxide (CO), volatile organic compounds (VOCs) and other greenhouse gases formed during combustion of vegetation and litter.

Many environmental factors affect how fuel will burn. In this project, we are investigating how the moisture content of green and dead plant material affects smoke composition and the amount of carbon lost during combustion.

METHODS

Leaves from *Eucalyptus saligna, E. bicostata and E. tereticornis* were cut from trees, weighed and either analysed immediately, air dried at 23°C for 24 hours, oven dried at 40°C for 24 hours or oven dried at 75°C for 24 hours before analysis. These materials were then combusted in a mass loss calorimeter (Fig. 1) at a heating intensity of 25 kW m^{-2}. Measurements of the CO_2 and CO emitted were made using infra-red gas analysers. VOCs were quantified using proton transfer reaction-mass spectrometer (PTR-MS) and identified using gas chromatography-mass spectrometry (GC-MS).

Figure 1: Mass loss calorimeter, PTR-MS and CO_2 and CO analysers

RESULTS

- CO_2 emission factors (mass of CO_2 released per kg of dry fuel burnt) decreased exponentially with increasing leaf moisture content (Fig. 2a).
- CO emission factors increased exponentially with increasing leaf moisture content (Fig. 2b).

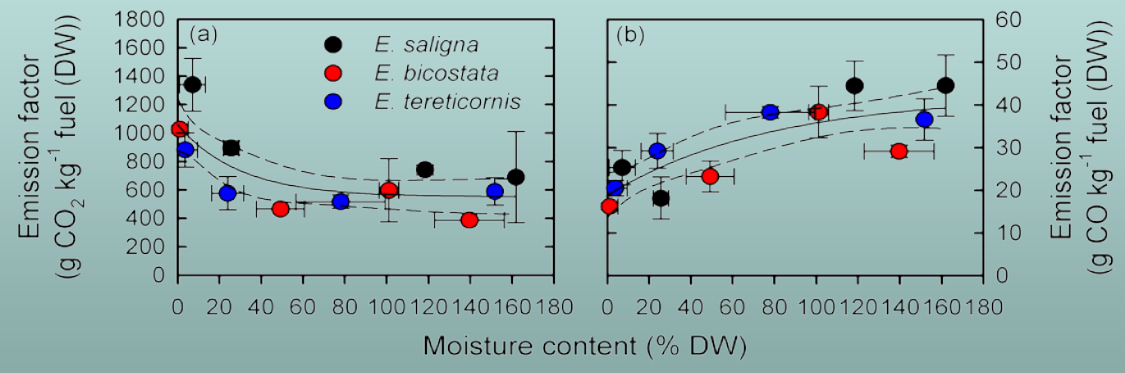

Figure 2: Effect of moisture content expressed on a leaf dry weight basis (DW) on (a) carbon dioxide (CO_2) emission factors and (b) carbon monoxide (CO) emission factors for three *Eucalyptus* species. In all panels values represent means ± 1 SD (n = 3). The solid lines represent non-linear regressions and the dashed lines the 95% confidence limits.

- CO_2 concentrations in smoke were highest from combusted leaves that had the least moisture.
- VOC concentrations followed the opposite pattern to CO_2 concentrations.
- There was no difference in CO concentrations measured across the moisture treatments.
- For all species tested, CO_2, CO and VOC concentrations in smoke were not measured in excess of short term occupational exposure limits (15 min average).
- 8 hour time-weighted average exposure limits were exceeded for some VOCs from leaves containing moisture.

Method	Compound(s)	ASCC (2010) [a] TWA (ppmv)	STEL (ppmv)	Fresh leaves (ppmv)	Air-dried leaves (23°C) (ppmv)	Oven dried leaves (ppmv)
IRGA	Carbon dioxide	5000	30,000	222 - 1689	763 - 2027	3579 - 5720
IRGA	Carbon monoxide	30	200	39 - 159	111-179	112-193
PTR-MS	Methanol	200	250	9.43 - 16.41	6.35 - 17.67	0.24 - 4.66
PTR-MS	Acetonitrile	40	60	0.38 - 4.15	1.35 - 3.72	0.58 - 2.48
PTR-MS	Acetaldehyde	20	50	4.74 - 9.41	4.55 - 9.89	0.10 - 2.80
PTR-MS	Acrylonitrile	2	-	0.01 - 0.24	0.12 - 0.32	0.02 - 0.24
PTR-MS	Acetone	500	1000	1.51 - 4.23	2.33 - 5.80	0.07 - 1.73
PTR-MS	Acetic acid	10	15	8.65 - 13.75	5.85 - 16.08	0.03 - 2.64
PTR-MS	Methyl ethyl ketone	150	300	0.83 - 1.91	0.95 - 2.07	0.01 - 0.48
PTR-MS	Benzene	1	-	0.10 - 0.53	0.30 - 0.77	0.09 - 0.48
PTR-MS	Methyl isobutyl ketone	50	75	0.04 - 0.19	0.08 - 0.20	0.00 - 0.04
PTR-MS	Toluene	50	150	0.30 - 3.81	0.64 - 1.63	0.03 - 0.67
PTR-MS	Phenol	1	-	0.68 - 1.58	0.79 - 1.98	0.03 - 0.57
PTR-MS	Xylenes	80	150	0.09 - 0.48	0.14 - 0.60	0.01 - 0.32
	Ethylbenzene	100	125			
	Benzaldehyde	-	-			

Table 1: Time integrated mixing ratios of carbon dioxide, carbon monoxide and volatile organic compounds resulting from the combustion of leaves of three *Eucalyptus* species compared to Australian occupational safety limits. [a] Australian Safety and Compensation Council. Volatile organic compound values for the air-dried (40 °C) treatment are not available.

CONCLUSION

An increase in leaf-level moisture content increases the concentration of VOCs measured in smoke while CO_2 concentrations decrease. The largest amount of gaseous carbon measured in the smoke generated from the laboratory combustion of *Eucalyptus leaves,* under any moisture condition, is in the form of CO_2.