



## Fighting Smoke When Fighting Fires

Personal exposures to bushfire air toxics

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Bushfire CRC Air Toxics Project

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## Bushfire Air Toxics – *Where there's fire there's smoke (and people)!*

**Air toxics are the diverse range of air contaminants (gases and particles) that occur in complex mixtures to which a person can be exposed with potential damage to his/her health**

- Fighting fires is a workplace and the fire fighter OHS must be protected (burn protection ✓ air toxics ✗ physiology ✗ decision-making ✗)
- Bushfire smoke in Australia – composition and the factors of influence (fuel type and load, fire intensity, weather etc) are unknowns
- Bushfire fighting practices in Australia – impact on exposure unknown
- Previous research limited (largely by US Forest Service)
- Bushfire CRC project: **Personal Exposure of Fire Fighters to Air Toxics and OHS Risk Management Strategies** (commenced 2004)
- Project plan
- Air toxics from fuels in Australia
- Fire season 2005 results



## Project Plan

### Bushfire Air Toxics

- Review of Australian/international literature/ Experimental burns with different fuels → key air toxic species to which fire fighters may be exposed
- volatile organic compounds (benzene, toluene, furaldehyde, phenol), aldehydes (formaldehyde, acrolein), CO, respirable particles (composition), PAHs, dioxin
- Selection of methods/procedures for measuring personal exposures
- Personal exposures measured over 4 fire seasons:
  - in all States and Territories
  - fire types – experimental burns, prescribed burn, wildfire
  - fire fighter tasks (truck driving, hose suppression, tool suppression)
  - fuel type (hardwood, softwood, grassland)
- Identify areas of unacceptable risks (occupational/environmental exposure criteria)
- Develop risk reduction strategies and assess in 1 fire season
  - task rotation, hazard awareness training, personal sensors, protective equipment



## Air toxics from different forest litters

Controlled free burn of 25-120g of litter in a closed chamber → measure air toxics yields

### WE CAN IDENTIFY HIGHER HAZARD FUEL TYPES

Litter types	Pollutant Yields (mg/g)				
	Gravimetric particles	CO	Formaldehyde	Acrolein	Benzene
Cheltenham Pine	39	115	0.32	0.29	0.42
Darwin Sorghum Grass	1.0	30	0.06	0.05	0.06
Mt Dandenong Eucalyptus	5.6	63	0.07	0.09	0.22
Wombat State Forest Eucalypt.	10.9	70	0.05	0.11	0.16
W.A. Coastal Scrub (Banksia)	7.8	64	0.10	0.11	0.20



## Air toxics from different forest litters

Litter types	Pollutant Yields (mg/g)					
	Benzene	Toluene	3-Furaldehyde	Xylenes	Phenol	TVOC
Cheltenham Pine	0.42	0.30	0.40	0.13	0.35	7.0
Darwin Sorghum Grass	0.06	0.03	0.015	0.015	0.038	0.38
Mt Dandenong Eucalyptus	0.22	0.13	0.055	0.088	0.08	1.6
Wombat S.F. Eucalyptus	0.16	0.10	0.1	0.06	0.09	1.9
W.A. Coastal Scrub (Banksia)	0.20	0.11	0.076	0.045	0.1	1.5



## Air toxics – personal exposures to fire fighters

HEALTH HAZARD = POTENTIAL FOR HARM

HEALTH RISK = LIKELIHOOD THAT HAZARD WILL BE REALISED

- REQUIRES KNOWLEDGE OF PERSONAL EXPOSURES TO AIR TOXICS
- EXPOSURE IN RELATION TO FUEL TYPE, FIRE TYPE, FIREFIGHTER TASKS, FIRE AGENCY PRACTICES
- PERSONAL EXPOSURES OVER 4 FIRE SEASONS
- TO DATE: 6 PRESCRIBED BURNS
  - Kiewa Valley Eucalypt forest (Vic) (2)
  - Ferny Creek Eucalypt forest (Vic)
  - Deer Park grass (Vic)
  - Ngarkat Conservation Park mallee scrub (South Aust)
  - Territory Wildlife Park tropical forest (Darwin)



## Personal Monitoring Devices



Fuel Reduction Burn – Victoria  
Bushfire fighters wearing personal sampling devices

### Carbon monoxide

Dräger Pac III data-logging sensor measuring up to 2000 ppm CO in real time



### Aldehydes

UMEx100 passive sampler badge (DNPH adduct analysis)



### Respirable Particles

in real time by laser light-scattering  
• TSI SidePak (up to 20 mg/m<sup>3</sup>)



• pDR passive (up to 400 mg/m<sup>3</sup>)



### Volatile Organic Compounds (VOCs)

Perkin Elmer sorbent tubes operated by micropumps

### Respirable Particles and PAHs

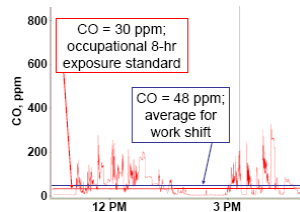
gravimetric filter sampling



## Examples of Personal Monitoring Devices

### 1. Carbon Monoxide

Dräger Pac III data-logging sensor measuring up to 2000 ppm CO in real time



GASTEC Colour Dosimeter Tubes  
Concentration range: 1.0-2000 ppm-hrs



## Examples of Personal Monitoring Devices



### 2. Respirable particles (<math><10\mu\text{m}</math>)

- in real time by laser light-scattering (TSI SidePak up to  $20 \text{ mg/m}^3$ ; pDR to  $400 \text{ mg/m}^3$ )
- averaged by gravimetric filter sampling



### 3. PAH analysis of gravimetric filters



## Summary of 2005 Personal Exposure Measurements

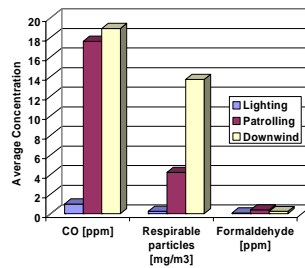
Sample	Work shift [h]	Avg CO [ppm]	Max CO [ppm]	Avg PM [ $\text{mg/m}^3$ ]	Max PM [ $\text{mg/m}^3$ ]
PE-140405	0.6	7.4	75	> 2.4	> 20
PE-200405	2.3	14.3	1005	> 1.4	> 20
PE-220405-l	1.5	0.2	28	0.2	8.1
PE-220405-p	0.8	20.2	297	> 4.6	> 20
PE-030505	2	4.5	154	> 1.1	> 20
PE-240505	6.5	48	1225	> 9	> 20
PE-240505	0.75	17.2	230	> 4.4	> 20
PE-220605	3	16.0	237	8.5	282
PE-220605	3	8.6	337	0.9	11.8
Occ. Exp. Std	4-8	30	400	6	-



## Summary of 2005 Personal Exposure Measurements

Preliminary results show that:

- CO levels sometimes exceed occupational exposure standards (avg 30 ppm, peak 400 ppm) with peak concentrations to 1225 ppm
- Respirable particle levels frequently exceed 20 mg/m<sup>3</sup> (goal 6 mg/m<sup>3</sup>)
- Major aldehydes present in bushfire smoke are formaldehyde, acrolein and acetaldehyde (irritants, carcinogens)
- Major VOC is benzene
- Different exposure levels to air toxics according to tasks



## Future Work

Attend prescribed burns and accidental fires across Australia in order to measure and evaluate personal exposures to air toxics according to tasks, fuel and fire types.

Identify tasks and vegetation types leading to high exposure risk.

Measure and evaluate levels of air toxics at staging areas and downwind of major fires or burns (→ 'smoke signature' for firefighting; → community exposures during prescribed burn season)





## Future Work

Assess strategies to reduce personal exposures to air toxics through field trials:

- task assignment and task rotation - mix low/high exposure tasks; assign fire fighters to specific tasks
- personal exposure sensing - CO sensor to tell fire fighter to move to different area
- hazard awareness training – fire fighter responds on the field according to fuel/smoke classification
- personal protection – respirator with protection factor appropriate to type of air toxics and their exposure levels (if exposure = 10x standard, use respirator with >10x protection factor)



## Respirators are selected appropriate to risk

Particulate Respirator, 95% reduction, with nuisance level organic vapor reduction (below occupational exposure standards). Used in applications such as foundries, and petrochemical operations where nuisance organic vapors are present.



Dual airline respirator – used if chemical cartridge respirators have short service life or are not effective against one or more of contaminants



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