ASSESSING FIREFIGHTERS’ EXPOSURE TO AIR TOXICS IN BUSHFIRE SMOKE

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Firefighting Work Environment

BUSHFIRE SMOKE
- Carbon monoxide
- Respirable particles
- Aldehydes
- Volatile Organic compounds
What do we know?

United States

1. USDA Forest Service Pacific Northwest Research Station

2. National Institute for Occupational Safety & Health

Australia - Project Aquarius

Risk Assessment Framework

- **SOURCE**: Characterize bushfire environment - workplace
- **EXPOSURE**: Environmental monitoring
- **DOSE**: Medical condition
  - Short-term
  - Long-term
- **MEDICAL CONDITION**: Health monitoring
Occupational Exposure Standards

- Occupational exposure standards (ASCC)
  - Exist for a range of air toxics
  - Not ‘no-effect’ level
  - Best used to assess quality of work environment

- TWA - Time-Weighted Average concentration
  - 8-hour working day, 5-day working week
  - Sedentary work activity

- STEL - Short-Term Excursion Limit
  - for those compounds with acute effects

- Review OES for bushfire fighting work environment

- Varying work shifts
- Off-shift exposures
- Heavy workload
- Fatigue & heat stress
- Mixture of pollutants
Methodology

Sample within the breathing zone of firefighters

- Key tasks
- Fuel types
- Fire types
- Various agencies
Methodology

Additional sampling equipment set up on vehicles
Field Monitoring - Sample Distribution

- BUSHFIRES
- SB/HB
- EXP
- FRB
- Ignition
- Ignition/Patrol
- Supervision
- Patrol/Suppression
- Other
- VIC
- QLD
- NT
- TAS
- SA
Results - Variability Among Samples

Drivers
- Work activities
- Burn conditions
  - Terrain
  - Fire stages
  - Fire types
- Fuel characteristics
  - Fuel type
  - Fuel moisture
- Meteorology
  - Wind speed/direction
  - Inversions
Work Activity

**Ignition**
\[ CO_{ave} = 6.2 \text{ ppm} \]

**Patrol/Suppression**
\[ CO_{ave} = 22.2 \text{ ppm} \]

**Asset protection**
\[ CO_{ave} = 10.2 \text{ ppm} \]

**Blacking out**
\[ CO_{ave} = 2.5 \text{ ppm} \]

**Mop-up**
\[ CO_{ave} = 2.4 \text{ ppm} \]

**Ignition**
\[ CO_{ave} = 0.4 \text{ ppm} \]

**Patrol/Suppression**
\[ CO_{ave} = 21.5 \text{ ppm} \]
Burn Conditions

- **Ignition**
  - CO\(_{ave}\) = 0.3 ppm
  - CO\(_{ave}\) = 8.1 ppm

- **Patrol/Suppression**
  - CO\(_{ave}\) = 1.7 ppm
  - CO\(_{ave}\) = 68.2 ppm
CO Exposures - Carboxyhemoglobin Levels

Variables that affect COHb levels:

- CO concentration in air  
  *Exposure measurements*
- Exposure duration  
  *Data-loggers*
- Work activity (ventilation rate, CO diffusion rate)  
  *Physiology assessment – Project D 2.1*
- Background COHb level  
  *Endogeneous production - 0.4-0.7%*  
  *Smoking (1 pack/day - 5-6%; 2-3 packs/day - 7-9%)*
PROGRAM D: ASSESSING FIREFIGHTERS’ EXPOSURE TO AIR TOXICS IN BUSHFIRE SMOKE

→ Carbon Monoxide

Graph showing the concentration of Carbon Monoxide from 10:00 to 18:00 with the following key:
- Average CO
- TWA limit
- Peak limit

The graph indicates the concentration of Carbon Monoxide in parts per million (ppm) with peaks exceeding the TWA limit and the peak limit.
Carbon Monoxide

COHb [%] | SYMPTOMS, EFFECTS
---|---
5% | Potential for adverse cardiovascular effects
5-10% | Effects on performance of tasks requiring vigilance and on reaction time, potential headaches, dizziness, reduced work capacity
10-20% | Slight headaches, dizziness, slight breathlessness on exertion
20-30% | Slight to moderate headaches, nausea
30-40% | Severe headaches, vertigo, nausea
Respiratory Irritants

Potential health effects
- Nose and throat irritation
- Difficulty breathing
- Exacerbation of respiratory or cardiac illnesses
- Impaired lung function
Personal versus Vehicle-mounted Sampling

<table>
<thead>
<tr>
<th></th>
<th>Personal</th>
<th>Tanker</th>
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<tbody>
<tr>
<td>CO\text{ave}</td>
<td>21.0</td>
<td>10.6</td>
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<tr>
<td></td>
<td>8.0</td>
<td>5.2</td>
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<tr>
<td></td>
<td>210</td>
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</tbody>
</table>

![Graph showing carbon monoxide levels over time for personal and tanker sampling.](image)
Exposure Assessment

- Majority of exposure levels below OES

- Exceedances (average & peak)
  - CO and respiratory irritants
  - Small %, short fraction of time

- Major drivers of high exposures
  - Work activity: Patrol/Suppression > Ignition
  - Burn conditions: Terrain, lighting pattern
Potential Control Strategies

- Operational level: Task assignment and rotation (mix high/low exposure tasks; assign firefighters to specific tasks)

- Hazard Awareness Training: explain situations where exposure to air toxics is likely to be high and how exposure risk can be minimized

- Equipment:
  - use of respiratory protection
  - use of personal exposure sensors
SUMMARY

Environmental monitoring

- Primary step in evaluation of working environment
- Personal samples rather than ‘static’ samples
  - Ensure unbiased and representative samples
- Limitations
  - Limited amount of samples
  - Bushfires - Tanker based crews
  - No assessment of the received dose
SUMMARY

Next step . . . Assessing dose received

- Use of ventilation rates, workload, exposure durations to assess dose received
- Biological monitoring - takes into account differences between individuals in uptake, metabolism and excretion of toxics
  ex. COHb monitoring in exhaled breath

. . . Assessing health effects
SUMMARY

OHS standard appropriate for the fire ground

- Altered workshifts
- Heavier Workload
- Bushfire smoke particles
  
  *Chemical composition & physical characteristics determine biological effect*

- Interactive health effects - exposure to multiple toxic compounds
Future Directions

Develop an OHS toolkit

- OHS regulations and standards
- Personal exposure assessment
  - Characterising the risks (exposure levels)
  - Assessing the risks (Risk matrix)
  - Mitigating the risks (Residual risks)
    ⇒ Simplified on-going monitoring program, e.g. CO monitoring during 1 fire season
- Post Incident reviews of the effectiveness of the applied OHS strategy
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