Gas-Phase Polycyclic Aromatic Hydrocarbon Exposure During Prescribed Fire – Case Study

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Introduction

Wildland firefighters work in high smoke exposure conditions with little to no respiratory protection. Wildland fires emit large amounts of air pollutants known to cause adverse health effects. Wood smoke contains many hazardous air pollutants, including polycyclic aromatic hydrocarbons (PAHs), a class consisting of chemicals of two or more fused benzene rings. PAHs have been associated with increased cancer risk and immune dysfunction (1,2,3). Lower molecular weight PAHs exist in the environment in the gas-phase; while high molecular weight PAHs exist as particle-phase molecules. Past studies have demonstrated that open-air burning of wood generates more gas-phase PAHs such as naphthalene, phenanthrene, and fluorene than particulate phase PAHs (4,5).

Objective:

To assess levels of gas phase PAHs during prescribed burns in mixed conifer forests and chaparral near Orleans, CA.

Methods

Gas-phase PAHs were measured for five days in duplicate on one individual while patrolling the fire perimeter (holding), igniting the prescribed fire (firing), and extinguishing burning material post-fire (mop-up) during prescribed burns. Personal PAH air samples (N=10) were collected using XAD sorbent tubes attached to PAS-500 Micro Air Samplers which sampled at 0.2 L/min for 5 to 12 hours. Sorbent tubes were attached to the front shoulder strap of a backpack that was worn during each prescribed fire. Sample pumps were placed inside the backpack.

XAD sorbent materials was extracted with dichloromethane and then analyzed for PAHs on a Hewlett Packard 6890 gas chromatograph / mass selective detector (GC/MSD) with a (50%-Phenyl)-methylpolysiloxane fused silica capillary column.

Data collection occurred at a Prescribed Fire Training Exchange hosted by the Mid Klamath Watershed Council and The Nature Conservancy in the Klamath River region of California. All prescribed burns conducted were broadcast burns, where fire was applied directly to most an area.

Results

Firing **Holding** **Mop-up**

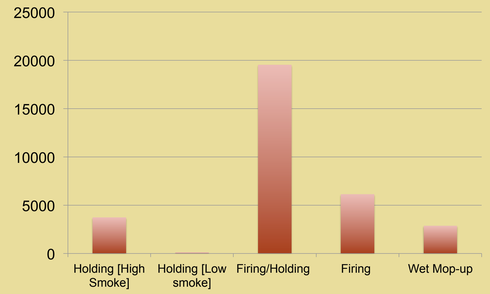
Tasks Performed

Day 1	Holding [High Smoke]	344 mins
Day 2	Holding [Light Smoke]	490 mins
Day 3	Wet Mop-up [Smolder]*	320 mins
Day 4	Firing and Holding	385 mins
Day 5	Firing**	771 mins

* Wet mop-up involved the use of water to extinguish smoldering fires

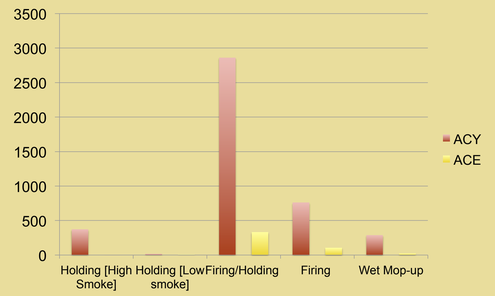
**Concentrations reported are based on one sample, not a mean of duplicate samples. Day 5 – pump failed.

Naphthalene Concentration (µg/m³)

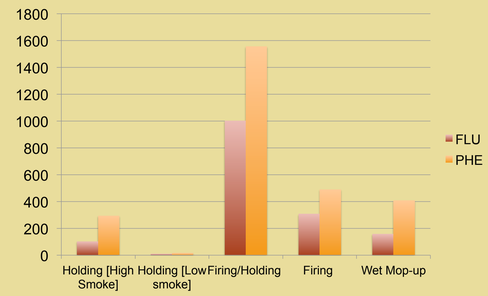


Retene Concentration (µg/m³)

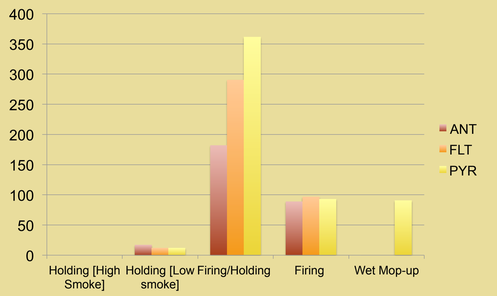
Acenaphthylene (ACY) and Acenaphthene (ACE) Concentration (µg/m³)



Phenanthrene (PHE) and Fluorene (FLU) Concentration (µg/m³)

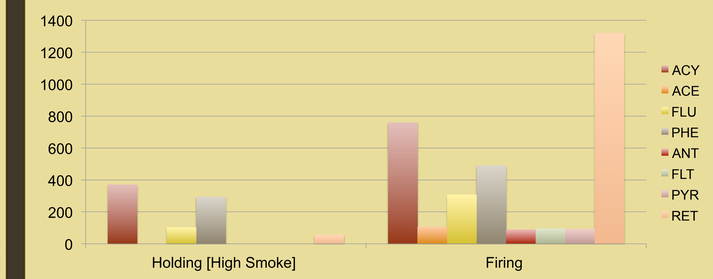


Pyrene (PYR), Anthracene (ANT) and Fluoranthene (FLT) Concentration (µg/m³)



Results

PAH Concentration (µg/m³) across job-task



Conclusion

Of the 9 PAHs that were measured, concentrations of NAP, PHE, ACE, FLU, and RET were consistently above detection limits. Concentrations of NAP, PHE, ACY, ACE, FLU, PYR were highest while firing and holding. For Day 2, all concentrations were below the limit of detection while holding; this was a low smoke producing fire.

The levels of NAP and PHE measured in this study were significantly higher than those measured in previous studies of wildland firefighters. Reh et al. detected ACE (1.0 µg/m³), ANT (26.5 µg/m³), and NAP (26.5 µg/m³) on a crewman at a Yosemite wildfire. During prescribed burning of woodpiles, Robinson et al. detected mean NAP (6.17 µg/m³), PHE (0.64 µg/m³), and FLU (0.83 µg/m³) in personal air samples.

Given the high concentrations of gas-phase PAHs detected in this small case study, more monitoring needs to be completed to characterize exposures from wildland fires.

Acknowledgements

This work was completed with support the Centers for Disease Control and Prevention National Institute for Occupational Safety and Health (NIOSH) Targeted Research Traineeship (T42 OH008429). We would also like to thank SKC for donating sampling equipment for this project. Charles Perrino for guidance in laboratory methods and the Mid Klamath Watershed Council and The Nature Conservancy for hosting me for the training exchange.

References

1. IARC (2002) Vol 82. International Agency for Research on Cancer, Lyon, France.
2. IARC (2010) Vol 92. International Agency for Research on Cancer, Lyon, France.
3. Nadeau K, McDonald-Hyman C, Noth E, Pratt B, Hammond SK, Balmes J, Tager I. Journ of Allergy and Clinical Immunology.Vol 126 (4) 845–852. October 2010.
4. Naeher LP, Brauer M, Lipsett M, Zelikoff JT, Simpson CD, Koenig JQ, Smith KR. Inhal Toxicol. 2007 Jan; 19(1): 67-106. Review.
5. Reh CM, Letts D, Deitchman S. Yosemite National Park, CA: US DOI, National Park Service; 1994. Health hazard evaluation report: HETA 90-0365-2415.
6.Robinson MS, Anthony TR, Littau SR, Herckes P, Nelson X, Poplin GS, Burgess JL. Ann Occup Hyg. 2008 Aug; 52(6): 497-508.

Photos:

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