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Occupational Health Challenges in Research

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Service Learning and Capstone Experience

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By

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ABSTRACT

Introduction: Employees working in universities and hospitals are faced with common and unique health and safety challenges. Usually, the campus Department of Health and Safety is tasked with reducing employee exposure through risk assessments**. Purpose:** In this study, we present a unique risk assessment case study related to a research project undertaken by the campus Department of Health and Safety (DHES). This project also describes the activities done by DHES to improve campus safety. We hypothesized that carbon monoxide, particulate matter, formaldehyde, and VOCs emitted from burning wood chips in a closed laboratory space will exceed regulatory and recommended exposure limits. **Methods**: We performed full-shift sampling to measure the indoor air quality of a laboratory that was burning wood with an electric smoker on three separate days. Sampling times varied from a duration of 2-5 hours over the three days. Area sampling with direct reading instruments was used on all three days. Passive sampling also occurred on all three days. Active sampling occurred on two out of the three days. Measurements for particulate matter, carbon monoxide, carbon dioxide, temperature, and relative humidity were recorded. The service learning projects included activities that integrated safety theory with practice. These included conducting risk assessments for laboratory hazards and updating the campuses' chemical hygiene plan. **Impact of the project:** This study provides guidance to campus health and safety personnel on how to approach unique research protocols from a health and safety perspective. It also underscores the importance of having proper engineering controls to mitigate exposure, and the intersection of health and safety, ethical research, and compliance issues. This information will assist future health professionals in determining the feasibility of using wood smoke in research laboratories. The service learning activities will have a direct impact on the safety and well-being of students, faculty, staff, patients, and visitors of UNMC and Nebraska Medicine.

Acknowledgments

First and foremost, I would like to thank Dr. Chandran Achutan for his critical eye, direct questions, and industrial hygiene experience. He not only made me a better researcher, but a better person. This project would not have been possible without him. Next, I would like to thank my preceptor Mrs. Miriam McCann. She is one of the most kind and genuine people I have ever met. Her insight into the field of health and safety will benefit me for the rest of my life. Although this project didn't incorporate many statistical analyses, I am grateful to have such a renowned epidemiologist in Dr. Lorena Baccaglini. Lastly, I want to thank the entire Department of Environmental Health and Safety. As a department, they made me feel incredibly welcomed and appreciated. Every employee took time out of their already busy schedules to answer my questions and expose me to the world of health and safety.

CHAPTER 1

INTRODUCTION

One of the challenges faced by academic institutions is managing an employee's exposure to chemical, biological, and physical hazards in the laboratory. To address this, the Occupational Safety and Health Administration has outlined a specific set of standards that provide rules to protect workers, including those who work in laboratories, from chemical hazards as well as biological, physical, and safety hazards (OSHA, 2011). Due to the unpredictable nature of research, laboratory managers must be diligent in their efforts to protect their workers. This type of oversight is typically performed by a health and safety office that assesses regulatory risk regarding laboratory safety. I was placed with the University of Nebraska Medical Center (UNMC) Department of Environmental Health and Safety (DEHS) for my Service Learning and Capstone Experience. The mission of DEHS is "to foster a culture of absolute safety for our students, faculty, staff, patients and visitors and to minimize environmental and regulatory risks to UNMC and Nebraska Medicine" (UNMC, n.d.).

My Service Learning experience with DEHS provided me with an enriching and working knowledge of complex health and safety issues. I was exposed to, and participated in, a diverse list of activities that include: laboratory safety, biosafety/biohazardous waste management, security, laboratory animal safety, occupational health and safety, chemical waste/hazardous material, dangerous goods, chemical hygiene plan, radiation organization/responsibilities, monitoring/survey, radioactive waste, and radiation training. The diverse and real-world knowledge that was obtained from this experience has significantly contributed to my understanding and passion for public health. I hope to build off these experiences and apply the principles that I obtained to combat some of life's most noteworthy public health problems.

During the fall of 2017, DEHS approached The College of Public Health (COPH) for assistance in assessing risk for a research project. A researcher on campus (referred to as "employee" was studying the effects of wood smoke on the lungs of rodents. The employee used an electric woodchip smoker in a closed laboratory space to expose rodents to smoke. We assessed the employee's exposure to chemicals from woodchip smoke and made recommendations for reducing exposure. This project is not only relevant to the field of public and occupational health but will also help fill a gap in knowledge related to uncommon forms of research in laboratories. Data from this study will assist the scientific community in assessing if the use of an electric woodchip smoker in a laboratory space is a practical option.

CHAPTER 2

LITERATURE REVIEW

Wood smoke is a complex mixture of gases and fine particles. These fine particles have the potential to cause a wide range of deleterious health effects. According to the EPA (2017), short-term exposures to particles from wood smoke can exacerbate lung disease, causing acute bronchitis, and asthma attacks. Previous studies have analyzed, and classified hundreds of chemicals found in wood smoke (Schauer et al., 2001; Cass & Simoneit, 2001; & McDonald et al., 2001). Due to their toxicity, the presence of VOCs and polycyclic aromatic hydrocarbons (PAHs) in wood smoke is of concern. Austin et al. (2001) characterized the presence of VOC combustion products in fire smoke. They discovered 14 VOCs that had significant concentrations in all the experimental fires. It was also discovered that benzene, toluene, 1,3-butadiene, naphthalene, and styrene were found at higher concentrations than other VOCs. Additionally, researchers from NIOSH (2013) sampled firefighter's exposure to VOCs, PAHs, and particulates in the air. Not only did the researchers find VOCs and PAHs, but they also determined that some PAH levels were above occupational exposure limits. A more recent study by Fent et al. (2018) characterized the area and personal air concentrations of combustion byproducts produced during controlled residential fires. These researchers concluded that personal air concentrations of total PAHs and benzene measured from some firefighters exceeded exposure limits. Additionally, they found that personal air concentrations of hydrogen cyanide exceeded the exposure limit for outside vent firefighters, with maximum levels higher than the immediately dangerous to life and health (IDLH) level.

Numerous studies have also looked at the effects of residential and occupational wood smoke exposure. Weinstein et al. (2017), found that women using wood-fueled chimney stoves were exposed to high levels of particulate matter. Furthermore, urinary PAH and VOC metabolites were significantly associated with wood smoke exposures. A similar study by Awopeju et al. (2017) observed the respiratory health of women working as street cooks in Nigeria. They found that the odds of reported respiratory symptoms were significantly higher among the street cooks than in control groups. In addition, they discovered that benzene concentrations in passive samplers worn by the street cooks was significantly higher when compared with the controls. Although this research provides compelling evidence regarding the risks associated with wood smoke exposure, a detailed literature review published by Naeher et al. (2007) found conflicting results. The researchers described how there is insufficient evidence at this time to conclude that wood smoke particles are significantly less or more damaging to health than general ambient fine particles. Another study conducted by Riddervold and colleagues (2012), found no statistically significant effects of wood smoke exposure on lung function. These researchers exposed human subjects to particle concentrations of about 200 micrograms per cubic meter ($\mu g/m^3$) to 400 $\mu g/m^3$. They concluded that short-term exposure to similar wood smoke concentrations found in high density wood burning populations' causes only a mild inflammatory response. An interesting aspect of this study is that the researchers elected to house the source of wood smoke in an enclosed container external to the laboratory. Another study by McDonald et al. (2006), sought to characterize hardwood smoke inhalation and also placed their wood burning stove external to the laboratory.

As can be seen, much of the current research regarding the risks associated with wood smoke inhalation is a complex web of variation. Moreover, identifying a study that looks at the occupational risks associated with wood smoke use in research laboratories has produced no results.

CHAPTER 3

ASSESSING WOOD SMOKE COMPONENTS IN A RESEARCH CONTEXT

Abstract

Objective: We assessed an employee's exposure to wood smoke in a laboratory. The smoke, from a wood chip smoker, was used to expose rodents in concentrated amounts. This is a modified system designed to minimize smoke leakage with heat-resistant tape and duct work that is connected from the woodchip smoker to the central exhaust system in the laboratory. We hypothesized that carbon monoxide (CO), particulate matter (PM), formaldehyde, and VOCs (benzene, toluene, and styrene) emitted from wood chips burning in a laboratory would exceed regulatory and recommended exposure limits**. Methods:** We conducted full-shift air sampling for particulate matter, carbon monoxide, VOCs, and formaldehyde over three days. Sampling times varied during each day of research. We used direct reading instruments to measure particulate matter during all three days. Additionally, passive sampling occurred on all three days. Active sampling occurred on two out of the three days. Ambient parameters such as carbon dioxide, temperature, and relative humidity were also recorded. **Results:** One particulate matter sample had a concentration of 0.98 milligrams per cubic meter (mg/m^3). DustTrak results for particulate matter ranged from below detection to 150 mg/m^3 over the three days of sampling and provided researchers with a profile of the environment over time. Values for carbon monoxide ranged from below detection to 67 parts per million (ppm). Benzene, toluene, and styrene were below the limit of detection. A formaldehyde sample exceeded the American Conference of Governmental Industrial Hygienist (ACGIH) threshold limit value of 0.1 ppm but was below the Occupational Safety and Health Administration (OSHA) permissible exposure limit.
Conclusion: The use of an electric woodchip smoker in a closed laboratory environment did not exceed regulatory and recommended standards for particulate matter, carbon monoxide, and benzene, toluene, and styrene. Low levels of formaldehyde were detected in the room and could be a source of exposure. Proper ventilation and engineering controls limited the number of particles and toxins in the air. If procedures or circumstances, including equipment and smoke delivery, are altered, this employee must inform campus health and safety for a reevaluation of the risk assessment.

Introduction

An employee at the University of Nebraska-Medical Center (UNMC) was studying the effects of wood smoke on the lungs of rodents. The employee used an electric woodchip smoker in a laboratory to expose rodents to smoke. The wood chip smoker was connected to the room's exhaust system. During the operation of the woodchip smoker, the room filled with smoke. One of the employees became physically ill while remaining in the laboratory. Employees in nearby laboratories complained of a strong odor of burning wood. The project was temporarily shut down until further tests could determine the viability of continuing this work. Additionally, the employee was required to improve the smoke capturing capabilities of the wood chip smoker.

These alterations included additional engineering controls such as adding more heat-resistant tape on all potential leak sites, additional ventilation ducts, and modifying the fan (Figure 1). During the fall of 2017, UNMC's Department of Environmental Health and Safety (DEHS) requested that the College of Public Health (COPH) assess if the employee's research was safe to proceed. Since the quality of air inside of a laboratory is a key determinant in worker health and safety, DEHS and the COPH collaborated to evaluate the air quality in the work space. We determined that the indoor air quality was possibly not compromised by use of the woodchip smoker. Proper ventilation and engineering controls limited the number of particles and toxins in the air (Appendix A).

However, due to other possible sources of exposure, we decided to extend the scope of the project. We then assessed the employee's exposure to carbon monoxide (CO), particulate matter (PM), formaldehyde, and volatile organic compounds (VOCs). We hypothesized that carbon monoxide, particulate matter, formaldehyde, and VOCs emitted from continued wood chip burning in an enclosed space will exceed regulatory and recommended exposure limits. This study describes a unique occupational health challenge in research laboratories.

Figure 1. Electric smoker connected to central exhaust system

Methods

To assess the indoor air quality of the laboratory, carbon monoxide, particulate matter, VOCs (benzene, toluene, and styrene), and formaldehyde were selected for sampling. Ambient air parameters such as temperature (T), relative humidity (RH), and carbon dioxide (CO_2) were also collected for the duration of the experiment. Sampling occurred over three days within a 5-day span. Sampling times varied between two and five hours. Area sampling for particulate matter was conducted on all three days by the employee using a DustTrak II Aerosol Monitor (TSI Incorporated. Shoreview, MN). Results from this direct reading instrument were provided to the researchers, who used the data as a semi-quantitative profile of the environment. Ambient parameters, such as carbon monoxide, carbon dioxide, temperature, and relative humidity were measured with an IAQ-CALC indoor air quality meter (TSI Incorporated. Shoreview, MN). This device was also being operated by the employee on all three days and supplemented our results. Log intervals for both direct reading instruments was set at 5 and 30 second intervals. Active area sampling for particulate matter was performed on two out of the three days. Measurements were collected using an SKC (Eighty-four, PA) air sampling pump that was set to a nominal flowrate of 1.0 liters per minute. Samples were collected on 37-mm Polyvinyl Chloride (PVC) filters. Field blank samples were collected each day. Sampling devices were placed approximately 12 inches away from the smoker on top of the exposure chamber that contained the rodents (Figure 2). Passive badges (ACS, Boca Raton, FL) were used to measure VOC and formaldehyde concentrations during all three days of sampling. Badges were placed in a central location near the room's ventilation system prior to the operation of the smoker. (Figure 3). These badges remained in place until after the smoker had been shut down. Additionally, badges were clipped to the employee's lapel and remained intact during the operation of the smoker.

Figure 2. Location and orientation of instruments

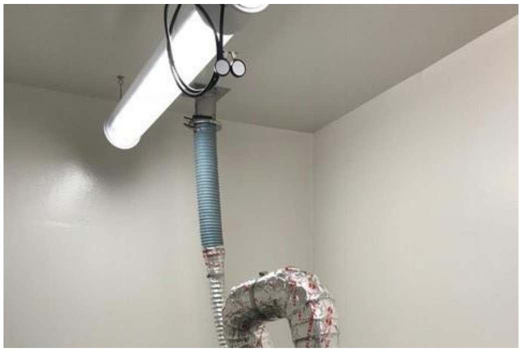

Figure 3. Passive badges above smoker

Results

Particulate matter samples were analyzed per the National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Method 0500 (NIOSH, 1994). One sample was above the limit of detection with a concentration of 0.98 milligrams per cubic meter (mg/m^3). DustTrak results for particulate matter were used semi-quantitatively to see the number of times the woodchip smoker emitted dust. These spikes only lasted for a short period of time and returned to baseline in between leaks (Figures 4). Values for carbon monoxide ranged from below detection limit to 67 parts per million (ppm). Day 3 results indicated a possible source of carbon monoxide exposure (Figure 5). Additional figures for particulate matter and carbon monoxide can be found in Appendix B. Temperature, relative humidity, and carbon dioxide values were within acceptable limits.

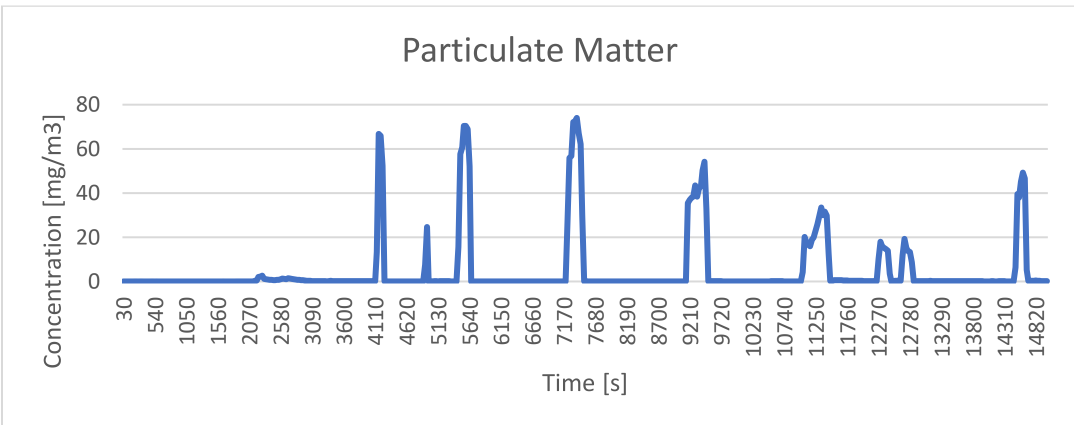

Figure 4. DustTrak results Day 1.

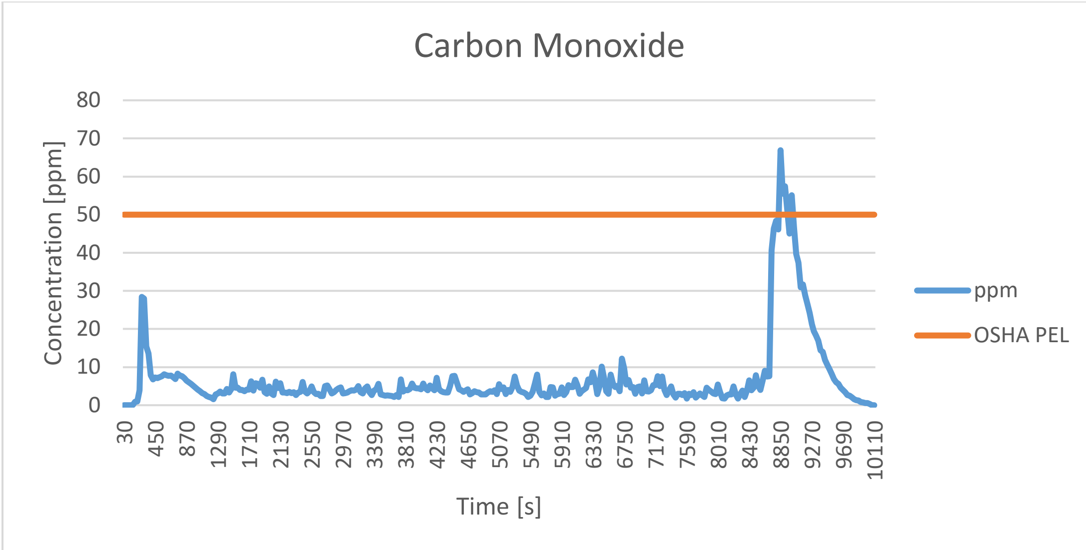

Figure 5. IAQ-CALC results Day 3.

VOCs were analyzed by The Occupational Safety and Health Administration (OSHA) Method 7 (OSHA, 2002) and Method 89 (OSHA, 1991). Formaldehyde was analyzed per NIOSH Method 2016 (NIOSH, 2003). Benzene, toluene, and styrene were below the limit of detection for both area and personal sampling. Personal sampling values for formaldehyde ranged from below detection to 0.06 ppm. Area sampling values for formaldehyde ranged from 0.05 ppm to 0.3 ppm.

All pollutant levels were compared to the OSHA permissible exposure limit (PEL) given as a time weighted average (TWA) over an 8-hour period. In addition, results were compared to The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs). The general industry PEL for particulates not otherwise regulated (PM) is 15 mg/m^3 TWA (OSHA, 2006). No TLVs currently exist for particulates not otherwise regulated. All values for particulate matter were within the OSHA PEL. The particulate matter spikes ranged from a duration of 30-seconds to six minutes for all three days of sampling.

The OSHA PEL for carbon monoxide is 50 ppm TWA (OSHA, 2006). The TLV for carbon monoxide is 25 ppm TWA (ACGIH, 2001). The maximum concentration recorded for carbon monoxide was 67 ppm over a 13 minute period measured on day three; thus, carbon monoxide did not exceed the OSHA PEL and the ACGIH TLV. The OSHA general industry PEL for formaldehyde is 0.75 ppm TWA (OSHA, 2006). The ACGIH TLV for formaldehyde is 0.1 ppm TWA (OSHA, 2006). All levels measured were low compared to OSHA permissible exposure limits. However, both area samples taken on day two for formaldehyde exceeded the ACGIH TLV.

Discussion

After comparing the sampling results to regulatory and recommended standards, researchers determined that the indoor air quality of the laboratory was not compromised on the days when we sampled. Most of the samples obtained were within regulatory and recommended standards. Direct reading results for particulate matter that were collected by the employee provided researchers with a particulate matter profile of the environment and supplemented our active sampling results. These devices were located just adjacent to the woodchip smoker and on top of the rodents' exposure chamber and aimed to capture any particulates that may have seeped out. Although results for carbon monoxide showed increased concentrations on day three, they did so for a brief moment in time. The OSHA exposure limit that was used is based off an 8-hour time weighted average; thus, all carbon monoxide values remained below the 50 ppm limit. Results obtained from passive badges indicated that formaldehyde was the only analyte above the ACGIH threshold limit value. This was seen for area sampling and not personal sampling badges. This observation aligns with the fact that the employee spent most of the time outside of the lab and only entered on occasion to take notes and assess the state of the rodents. These results suggest that burning woodchips in the laboratory is a possible source of exposure, so proper personal protective equipment (PPE) should be utilized before re-entry. Wearing a half or quarter face respirator with an organic vapor cartridge would provide the employee with the necessary protection while working in the laboratory. Although a written respiratory protection plan may not be required, administrators must adhere to certain obligations as outlined by OSHA for workers who voluntarily wear respirators on the job (OSHA, n.d.). Safety goggles should also be worn to protect from the occasional plumes of particulate matter and formaldehyde. Since the employee spent a majority of the time just outside of the laboratory, the risk of exposure was reduced. If employees must spend increased periods inside the lab, respirators should be mandated per exceedance of the ACGIH TLV.

The outcomes obtained from direct reading instrumentation showed slightly different results from preliminary findings in Appendix A. The data from the preliminary study showed a single spike in particulate matter when the smoker was turned on, but quickly resumed to baseline levels within 30-seconds and remained there for the duration of the study. Similar results were seen for this study, but there were many more spikes and for longer durations. A possible explanation for this difference is that the previous sample didn't include any of the rodents. This may have created an additional route of exposure as the smoke had to now travel from the smoker to the rodent exposure chamber. Additionally, the employee had to re-enter the laboratory at different intervals during this sampling period to open and close the valves to let smoke into the rodents' chamber as well as check on their health status. Results between each day of sampling also produced inconsistent results. A possible source for this inconsistency may lie in the methodology of taping up the woodchip smoker with heat-resistant tape. Due to human error, this may not be a reproducible technique. Although the woodchip smoker run times were approximately the same between both studies, this study produced more contaminants in the air. Small amounts of visible smoke were observed inside the lab during ignition of the smoker. Nevertheless, the data supports that the environment quickly resumed to baseline levels in between the spikes in concentration. These results indicate that the employee has made necessary alterations to the smoker that allow most of the smoke to be contained and funneled through the ventilation system. It is for these reasons that researchers recommended that the employee's research be allowed to continue.

A strength of this study was that researchers were able to implement both active sampling tools and direct reading instrumentation. Having both available allowed researchers to better compare the environments within the laboratory, but results obtained from the DustTrak appeared to yield more particulate matter than active sampling. This could be the case for a variety of reasons. One, the direct reading instrument may be more sensitive to detecting certain dust particles that could not be contained on the filter media. The DustTrak uses a light-scattering photometer method that quickly counts particles and translates them into a specified concentration in a matter of seconds. The active sampling pump collects total dust onto a sampling media and is analyzed using a gravimetric method based off total mass. The DustTrak results supplemented by the employee provided us with a good approximation of what is happening in the environment at a specified time, but the sampling pump provided us with a more accurate representation of total particulate matter. Lastly, being able to implement both area and personal sampling methodologies was a strength as it allowed us to better assess the employee's risk of exposure. Area sampling allowed us to assess if the smoke in the room was being properly captured and effectively ventilated.

Despite the strengths of the study, there were some limitations. Due to the complex nature of wood smoke, using a device that captures a wider range of VOC analytes would have been more advantageous than just sampling for three VOCs. Due to budget limitations, we were unable to implement this methodology. In our analysis of area sampling, it would have also been beneficial to place additional passive badges in random locations throughout the laboratory. This information could have supplemented our conclusions about the overall air quality in the laboratory.

This study sheds light on the occupational challenges that exists within research; especially when trying to recreate variables that would normally occur on a large scale and in an outdoor environment. The variability and novelty that comes along with research can expose employees to any number of chemical, physical, and biological hazards. In pursuit of their work, many employees may overlook the health risks that the project has on them and their team. Though the Department of Environmental Health and Safety plays an integral part in an investigator's safety, they may not be equipped with the tools necessary to assure safety for complex and unusual research studies. Continued, in-depth risk assessments and job safety analyses must be performed to monitor the health and safety off all employees performing their work.

Conclusion

Woodchip smokers in a laboratory should be used in a dedicated space with proper ventilation and engineering controls. Use of heat tape and ventilation alone may not be enough to eliminate all exposure. Although most pollutants were below recommended and regulatory standards, two formaldehyde samples exceeded the ACGIH TLV.

Recommendations

Although this woodchip smoker will no longer be used in this configuration, researchers are encouraged to use a smoke-generating device outdoors and pipe the smoke indoors. In addition, we offer the following recommendations specific to the use of the woodchip smoker used in this study:

1. Design a woodchip smoker with more robust engineering controls. Do not rely on heat-resistant tape alone to prevent leaks.
2. Wear a half or quarter face respirator with an organic vapor cartridge. Comply with the UNMC respiratory protection plan.
3. Wear safety goggles to protect from plumes of particulate matter and formaldehyde.
4. If research deviates from approved protocols, the Department of Environmental Health and Safety must be informed. Additional risk assessment will likely be necessary.
5. Work with health and safety professionals during the development phase of the research.

Chapter 4

Service Learning Experience

Working with UNMC's Department of Environmental Health and Safety was an extremely enriching and constructive experience. I learned that this department is composed of an eclectic group of determined and skillful individuals who are committed to the health and well-being of all faculty, students, staff, patients, and visitors at UNMC and Nebraska Medicine. Their dedication to safety was apparent from the first meeting that I attended. In addition, their welcoming and considerate nature made my arrival that much more pleasant. During my time with DEHS, I was exposed to a wide-range of activities and processes that built upon my knowledge of health and safety. These activities can be divided into the following three categories: general safety, chemical safety, and radiation safety. Furthermore, these categories can be divided into sub-categories and are as follows: research laboratory safety, biosafety/biohazardous waste management, security, laboratory animal safety, occupational health and safety, training, chemical waste/hazardous material, dangerous goods, chemical hygiene plan, radiation organization/responsibilities, monitoring/survey, and radioactive waste management. I will provide a detailed account of my activities and responsibilities within each sub-category. Next, I will outline my contributions, strengths, and challenges as they pertain to my service learning experience. Lastly, I will describe how my views of public health practice have been impacted and explain how my previous public health education benefited me throughout this process.

- General Safety
  - Research Lab Safety
    - Much of the work that DEHS manages is related to research laboratory health and safety. They are responsible for conducting annual laboratory audits. I had the pleasure of attending numerous laboratory audits during my time with DEHS. The laboratory audits are completed in accordance with EPA, OSHA, and DOT regulations. Each governing body has a specific set of conditions that each principal investigator (PI) must adhere to. These may include, but are not limited to, hazardous material handling, storage, disposal, emergency procedures, general safety, facilities, electrical, security, and signage. Prior to the audit, each laboratory must complete an environmental, occupational, and transportation related checklist. Page 1 of the laboratory safety checklist used by this department can be found in Appendix C. The employee conducting the audit then compares the details of their findings to the responses on the checklist. Following the audit, a formal report is generated, and specific recommendations may require follow-up. The PI and all laboratory personnel must sign the audit report; confirming that they understand the findings and recommendations.
  - Biosafety/Biohazardous waste
    - Although UNMC's biosafety department is not based out of DEHS, an employee within the department assists in the management of research protocols and procedures related to laboratory animal use. Currently, all these procedures must be approved and monitored by UNMC's Institutional Biosafety Committee (IBC) and Institutional Animal Care and Use Committee (IACUC). This employee directed my attention to

the CDC's 5th edition of Biosafety in Microbial and Biomedical Laboratories (BMBL) manual and The Association of Biosafety and Biosecurity (ABSA). I spent some of my time in the department reviewing this manual and familiarizing myself with the association. Additionally, I assisted this employee with identifying standard operating procedures for Tetrodotoxin, Picrotoxin, and Bicuculine because their department had to determine how and where to dispose of these toxins. The DEHS department also coordinates the disposal of all biohazardous waste with an outside vendor. Biohazard waste is defined as materials of biological origin capable of producing an infectious disease in humans or animals and includes blood, body fluids, discarded sharps, and inoculated culture media (UNMC, 2015). Workers must ensure the safety of all personnel involved by utilizing the properly labeled biohazard bags, containers, and labels prior to vendor pick up.

- Security
    - This is another department that is not directly based out of DEHS, but UNMC's safety manager resides within the department and works closely with the Security department. He has been a part of UNMC for over 30 years and is involved in a multitude of services related to safety, security, emergencies, and disasters. During my time with DEHS, I had the opportunity to participate in safety committee meetings that bring together a diverse team of professionals from UNMC and Nebraska Medicine. These meetings consisted of various topics related to campus safety and security. I was involved in conversations regarding intruders, threats, lockdowns, injuries, and medical outbreaks. It was stimulating to see a team of professionals committed to the health and safety of all staff, students, and visitors. In

addition, once a decision was made regarding a new policy or procedure, they reported back to their respective departments and the change was made. Specifically, they discussed a policy of closing doors to a wing for security purposes and I noticed it was closed the following day.

- Laboratory Animal Safety
  - Another employee that was recently integrated into DEHS oversees procedures and protocols related to animal use and safety of personnel who work with them. During my time with DEHS I was able to see some of the animal research facilities. I spent numerous hours reviewing the Institutional Animal Care and Use Committee's (IACUC) regulations that are used on campus. All employees who work with research animals must receive a medical screening before working with animals and all activities related to animal research must be approved by UNMC's committee. Any minor changes in procedures or protocols must be reviewed and approved by the committee prior to implementation. Daily audits must occur for all lab animals to look for changes in behavior, living environment, and health. Another interesting protocol are the sentinel rodents' that are used within the labs. These rodents serve as a type of control for possible contaminants or environmental changes that may occur with the animals themselves. Bedding from each rodent's cage is added to the sentinel rodent's cage at a specific time interval. The sentinel rodent is then observed for changes in behavior and health status and tested for pathogens periodically. UNMC is accredited by the Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC) since the 1960's and was one of the first universities to be accredited by this agency. This is a private, nonprofit organization

that promotes the humane treatment and care of animals. Universities like UNMC voluntarily elect to have AAALAC visit and evaluate their programs for animal care and use. These assessments not only help with IACUC inspections, but they also set a precedent for humane animal care in research.

- Occupational Health and Safety
  - During my time with DEHS, I attended weekly occupational health meetings that cover all issues related to employee health and wellness. This is a rather new area of DEHS that is currently under construction, but the employees who are involved in these discussions are passionate about employee health. Topics discussed in these meetings include, but are not limited to: indoor air quality, respirator fit testing, ergonomics, vaccines, chemical exposures, screening procedures, and audits.
- Training
  - Much of the work that DEHS does is related to employee training and education. The first training that I participated in was radiation safety training. This was a two-part training that included an online portion that took about three hours to complete and an in-person training that took another five hours. This training is primarily for authorized users who plan to work with radioactive material. This training taught me about half-lives, survey meters, calibrating survey meters, sources, decontamination, and responsibilities. Following radiation training, I participated in an 8-hour HAZWOPER refresher training. This training was focused on the procedures and polices surrounding the cleanup of hazardous material incidents. The training was taught in accordance with OSHAs 29 CFR 1910.120(q)(6). HAZWOPER applies when there is a release of a hazardous substance or where an uncontrolled release is

probable. The training provided me with foundational knowledge of OSHA regulations related to hazardous material cleanup. Additionally, I was introduced to a variety of personal protective equipment and supplies (i.e. Tyvek suits, respirators, gloves, spill pads, IAQ monitors, etc.) I learned about the different levels of response and that DEHS is only capable of providing up to level C cleanup. This means that approved respirators can be used instead of a self-contained breathing apparatus (SCBAs). This level does not provide protection in oxygen deficient environments, so DEHS must call the fire squad if this type of incident occurs.

- Chemical
  - Hazardous Waste/Hazardous Material
    - During my time with DEHS, I learned that Chemical and Hazardous Waste is any chemical material for disposal and includes both hazardous and non-hazardous chemicals. This department is responsible for the "cradle to grave" management of all chemicals, in accordance with Occupational Health and Safety Administration (OSHA) and Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) regulatory requirements (DEHS, n.d.). This means that DEHS is responsible for ensuring that chemical and hazardous waste is being retrieved, used, stored, shipped, and disposed of in accordance with these requirements and regulations. According to the EPA, "Hazardous waste is generated from many sources, ranging from industrial manufacturing process wastes to batteries and may come in many forms, including liquids, solids gases, and sludges" (EPA, n.d.). Each regulatory body has its own definition of what is considered hazardous waste, but each are primarily concerned with the waste's potential to cause harm to humans,

animals, or the environment. Hazardous *waste* is a term used by OSHA, EPA, and RCRA. Hazardous *material* is a term used by the Department of Transportation and is any item or chemical which, when being transported or moved in commerce, is a risk to public safety or the environment (IHMM, n.d.).

- Dangerous Goods
  - Dangerous goods are defined as articles or substances which are capable of posing a significant risk to health, safety, or property when transported and are classified by the International Civil Aviation Organization (ICAO) and/or the International Air Transport Association (IATA) as dangerous goods. The shipment of hazardous materials or dangerous goods requires UNMC to comply with regulatory requirements. All employees who ship hazardous materials or dangerous goods, which includes dry ice, Category A Infectious Substances affecting humans and/or animals, Category B Infectious Substances (biological substances), patient specimens (exempt human or animal specimens) and cultures, shall follow regulatory requirements based on the mode of transportation (UNMC, 2013). During my participation with DOT laboratory audits, I observed workers reviewing shipping binders to ensure proper documentation. Correct labeling and filing is the primary focus of DOT audits. I also participated in a FedEx training with a representative that walked us through the process of using their software and web-based shipment programs.
- Chemical Hygiene Plan
  - OSHA's Occupational Exposure to Hazardous Chemicals in Laboratories standard

(29 CFR 1910.1450), referred to as the Laboratory standard, specifies the mandatory requirements of a Chemical Hygiene Plan (CHP) to protect laboratory workers from harm due to hazardous chemicals. The CHP is a written manual stating the policies, procedures and responsibilities that protect workers from the health hazards associated with the use of hazardous chemicals in the workplace. During my time with DEHS, I was tasked with revising, re-formatting, and adding to their current CHP. This became one of the major focuses of my time with DEHS and will be further explored in my discussion.

- Radiation
  - Organization/Responsibilities
    - I learned that there are five categories of people or persons that makeup UNMCs Radiation Safety Program. They are as follows: Chancellor, Radiation Safety Committee (RSC), Radiation Safety Office (RSO), Authorized User (AU), and Radiation Workers. Each category has their own set of roles and responsibilities as they pertain to radiation safety. Based on the scope of my project, I only became familiar with the RSO, AU, and radiation workers. The RSO is based out of DEHS and is composed of a group of trained health physicists and technicians who ensure compliance to regulations and policies as outlined by the RSC. AUs are the groups of researchers who are authorized to use radioactive material in their clinic research and/or laboratory research activities. The RSO manages the AUs training which allows them to work with radioactive material. From what I observed, these are typically the primary investigators and medical doctors on campus and in the hospital. Additionally, the RSO performs audits and provides technical support to the AUs.

Radiation workers are the individuals who engage in clinical and laboratory research activities where they handle the material that produces ionizing radiation. These individuals are under the direct supervision of the AUs.

- Monitoring/Survey
  - Individuals who work with radioactive material can receive radiation doses both internally and externally. State regulations require that UNMC must monitor exposures to radiation and radioactive material at levels satisfactory to show compliance with the regulatory dose limits (UNMC, n.d.). Dosimeters are used to measure external radiation doses and bioassays are used to measure internal doses. While working with DEHS, I noticed that all of their workers who have the potential to work with ionizing radiation were wearing these dosimeter badges. Surveys are performed in all areas where radiation is used to identify any possible contamination and to ensure levels are kept As Low As Reasonably Achievable (ALARA). This acronym is a basic requirement of current radiation safety practices and means that every reasonable effort must be made to keep the dose to workers and the public as far below the required limits as possible (UNMC, n.d.). These types of surveys can be divided into five different methods of sampling: General Use, Instrument, Wipe, Exposure Rate, and Air Concentration Survey. During my radiation training, I had the opportunity to learn more about how these surveys operate and the methods behind their use. One of my first job shadows consisted of watching a worker calibrate these different types of instruments.

- Waste
  - The DEHS department must adhere to specific guidelines for radioactive waste as outlined by the United Stated Nuclear Regulatory Commission (NRC). DEHS has developed extensive and transparent guidelines for the disposal of radioactive material. Authorized users and workers must properly label and store all radioactive solids, liquids, and carcasses in accordance with these guidelines. Failure to do so could result in the authorized users' loss of privilege to work with radioactive material; which could have dire consequences for their research. Due to the methods of disposal as outlined by the RSO, radioactive material must be separated by radionuclide when possible. This allows the RSO to properly store and dispose of the radioactive material based on individual half-lives. While job shadowing a technician that is responsible for picking up waste, I was fortunate enough to see the new storage facility that houses all the radioactive waste in large drums. Each one was labeled based on the rate of radioactive decay activity. Once the radionuclide has completely decayed, DEHS staff is able to dispose of it as they would regular waste.

Service Learning Discussion

As can be seen, working with the Department of Environmental Health and Safety provided me with a diverse and real-world knowledge that has benefited me in ways I never thought were possible. I previously knew very little about chemical, radiation, and hazardous material safety. Being exposed to such a varied nature of regulations and procedures has greatly strengthened my understanding of these fields. This experience has augmented my desire and passion to work in the field of health and safety. Although I feel this experience benefited me more than the DEHS department, I feel accomplished regarding my contributions to their cause. From day one, I felt comfortable interacting in meetings with professionals who I previously had no associations with. I was never afraid to ask a pertinent question or offer my input regarding a past, current, or future issue. I was confident in the education and experiences that I have received, but also understood when my knowledge and/or experience were unqualified for the subject at hand. I felt that I brought in a fresh set of eyes and unbiased opinions that hopefully deepened discussions and helped those in need. My second most significant contribution was related to my work with the Chemical Hygiene Plan. This manual is one that has undergone numerous revisions and has been in development for some time. Once I was tasked with lending a hand in the continued development of this project, I immediately began looking through other universities CHP manuals to understand the scope of the project. Over the next couple of months, I began to work with another employee within DEHS who had previously been working on the project. Due to the complexity of the project, we met on several occasions to discuss the direction we were heading. Since the manual was in development, many of the sections needed further elaboration and clarification. We sent numerous emails and met with the DEHS Chemical Director and Executive Director to determine what sections to keep, delete, and/or further explain. Once roles were assigned, we both began to diligently work our way through the manual. This involved citing specific regulatory definitions, working with outside professionals, mapping it with the lab safety manual, integrating links from the lab safety manual, identifying fact sheets, and reformatting the entire manual.

In terms of my strengths, I have always prided myself on my interpersonal communication skills, professionalism, and punctuality. Being comfortable and able to speak with strangers in an academic setting is a trait that I am forever grateful for. Using these communication skills to contribute to purposeful meetings regarding health and safety was a trait that I hope DEHS benefited from. Being professional and on time are traits that are extremely important to who I am as a person in and out of the academic setting. Appropriate attire, respect, manners, humility, empathy, and attention to detail are also traits that I strive to incorporate into my everyday life. I believe that I displayed this level of professionalism during all times throughout my Service Learning and Capstone experience.

There were a few hindrances throughout the project that I didn't anticipate happening. One, I couldn't start each portion of my project as soon as I would have liked. Some of this was related to unforeseen family emergencies, but I was also dependent upon other individuals' schedules before I could begin air sampling and working with DEHS. I didn't begin collecting hours for my Capstone project until late January and Service Learning hours until late February. This late start drastically delayed the number of hours I was able to obtain and became a significant source of stress. Also, I wish I would have spent more time with my committee chair in the beginning to better understand each other's expectations. I believe that having transparent and detailed objectives from day one would have kept me on track with my project. If this were to happen again, I would be more diligent in my communication to speed up the start of my project. Second, I had some issues obtaining access to secured areas and difficulties with parking. In terms of access, I just had to reach out to the necessary individuals to obtain clearance. I was never able to obtain the proper parking access but was able to make the necessary accommodations. My last challenge was again related to time-management. I underestimated the amount of time that was involved in taking both Service Learning and Capstone together. In addition, I was working, taking an online class, and raising a family. I overcame these obstacles by utilizing a variety of organizational tools like calendar reminders and sticky notes. If I were to go through this again, I would better plan out my semesters and not take both experiences at the same time.

Participating in the SL/CE experience has had a direct impact on how I view public health practice. First, it was refreshing to see professionals so passionate about the health and safety of others. In the modern era, we are continually bombarded with bad news and negative thought, so working with individuals committed to the “greater good” was a heartening experience that will never be forgotten. On the other hand, it was frustrating to see how money and politics are once again at the forefront of many organizations. This is particularly frustrating in the field of health and safety as DEHS departments are typically not revenue generating entities. When a department must exist but doesn’t bring in any revenue, the availability of resources may be scarce. I hope to take the insight I gained from this experience to show more companies that investing in the health and safety of their employees has the potential to increase productivity, revenue, and work satisfaction. Companies should focus their effort, time, and money on preventing workplace injuries, rather than fixing workplace injuries. I believe this experience has helped prepare me for the difficult discussions that go into fighting for what you believe in. Specifically, always fighting for worker health and safety.

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Appendix A: Previous findings

Indoor Air Quality of a Research Laboratory (December 2017)

Anthony Blake, Chandran Achutan, PhD, CIH

Abstract

Objective: The purpose of this study was to determine the feasibility of doing research with a wood burning smoker in an enclosed space. Additionally, researchers sought to determine if the wood smoke affected other employee's in adjacent labs. **Methods:** Researchers measured the indoor and outdoor air quality of a lab that was burning wood with an electric smoker on two separate days. Data was recorded one hour prior to the smoker operating, two hours during the operation, and one hour following operation. Active sampling pumps and direct reading instruments were utilized. Measurements for total dust, carbon monoxide, carbon dioxide, temperature, and relative humidity were recorded. **Results:** Five out of the six samples taken on day one with active sampling pumps came back below the limit of detection; with one sample showing 1.8 mg/m^3 of total dust over a two-hour operation period. Data for the direct reading instruments were inconclusive on day one. On day two, the direct reading instrument measuring dust recorded a data point of 60.7 mg/m^3 within the two-hour operation period. Carbon monoxide, carbon dioxide, temperature, and relative humidity were all within OSHA's permissible exposure limits (OSHA, 2016). **Conclusion:** The indoor and outdoor air quality was not compromised by use of the wood burning smoker. Proper ventilation and engineering controls limited the number of particles and toxins in the air. Researchers recommend that the use of a wood burning smoker in an enclosed space is safe for use if proper controls have been implemented. More research is needed to determine if other chemicals, such as VOCs and PAHs, compromise the indoor air quality of the laboratory.

Appendix B: Additional Figures

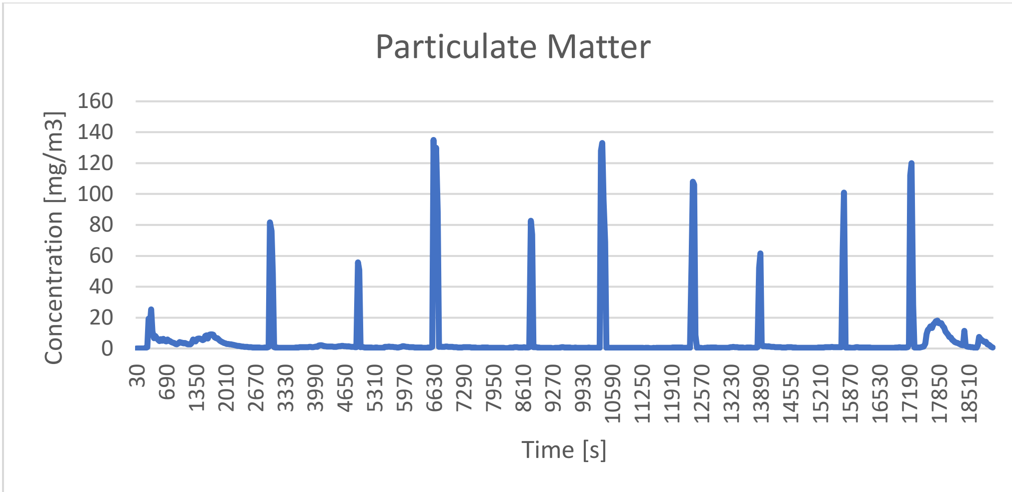

Figure 6. DustTrak results Day 2.

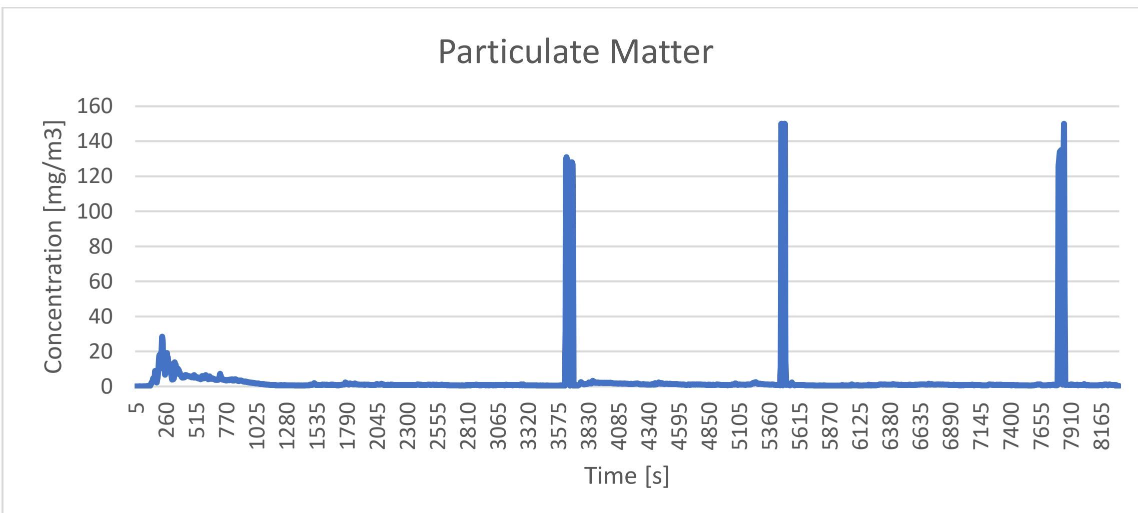

Figure 7. DustTrak result Day 3.

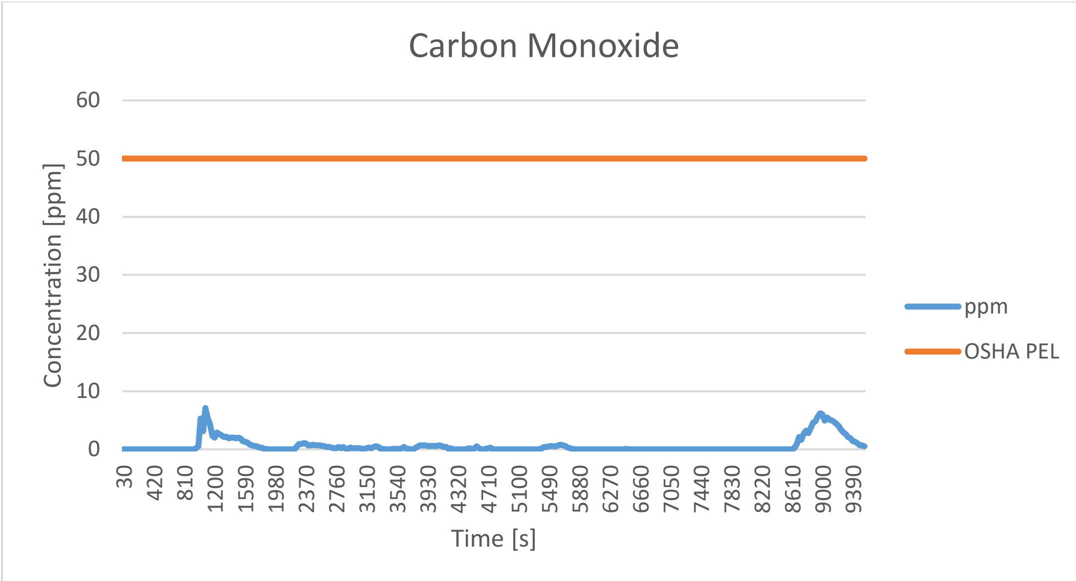

Figure 8. IAQ-CALC Results Day 1.

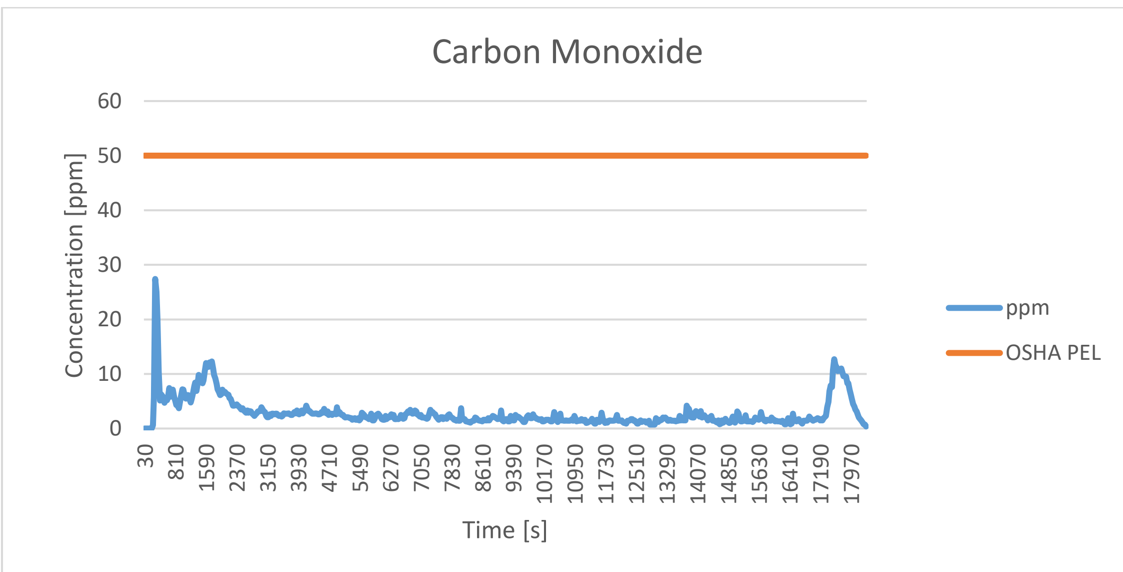

Figure 9. IAQ-CALC Results Day 2.

Appendix C

UNMC Environmental Health and Safety
Laboratory Safety Checklist for
EPA and OSHA Regulations Audit

Date:	**Building & Room(s):**
Principal Investigator(s):	
Primary Contact:	**Phone:**
Person Responsible for Lab Safety Oversight:	**Department Administrator:**

The laboratory safety checklist should be reviewed by the laboratory PI and all laboratory personnel. Once the checklist has been completed and reviewed, the PI and all lab personnel should sign the last page of the checklist.

Please be prepared to submit a completed and signed checklist, at the time of your audit.

If you have any questions regarding items on the checklist, please contact Environmental Health and Safety (EHS) at (402) 559-6356 or unmcehs@unmc.edu

	HAZARDOUS MATERIALS (HM)	YES	NO	N/A	EXPLANATION / INFORMATION
1	**Have all individuals working in the lab been educated in the hazards present within the lab space(s)?** *This includes hazards associated with equipment, stored energy, pressure vessels, hazardous chemical reactions, shock sensitive substances, flammable/explosives, etc.*				All lab personnel should be aware of the hazards present and take the necessary steps to minimize or eliminate them. All employees/students in laboratories must know what personal protective and safety equipment is available, when it is required, how to use it, when it is not safe to use and how to dispose it.
2	**Has a risk hazard assessment been conducted for all chemicals, substances and processes that pose a physical risk and/or health hazard?** *This may include chemicals that are flammable, air or water reactive, explosive, corrosive, toxic, etc.*				Risk hazard assessments should take into consideration ways to minimize or eliminate exposures to the physical and health hazards through the use of engineering controls, barriers, substitution and/or personal protective equipment. This is also important so lab personnel know which chemical spills they safely clean and which they need to call for assistance.
3	**Are Safety Data Sheets (SDS) and other references readily accessible to lab personnel for ALL chemicals/substances present in the lab space(s)?**				Individuals should review SDS (formerly known as MSDS) information prior to working with any chemicals or substances. Appropriate PPE should be used, as outlined on the SDS. A check should also be made to determine if an SDS is available in the online SDS database at: https://msdsmanagement.msdsonline.com/ddb19e69-2fb7-4723-9c8b-e8ff4dd13e03/ebinder/?nas=True
4	**Are all chemicals stored by hazardous class and compatibility?** *Solids are stored above and liquids below. Oxidizers are not stored with organics. Flammable liquids are stored in an UL/FM approved flammable liquids cabinet, with a self closing door that is latched shut.*				Proper chemical storage is as important to safety as proper chemical handling. Proper chemical storage is a requirement for any lab using hazardous materials. Chemicals shall be organized by compatibility, clearly labeled with full chemical name (no abbreviations) and in good condition. (For example it is dangerous to store acids with bases and/or flammables with corrosives). A one day "working " supply of flammables is all that is allowed to be kept outside of an approved storage room (ASR) or flammable liquids cabinet. **Chemicals shall not be stored in a fume hood or bio safety cabinet.**
5	**Are all used chemicals stored compatibly in secondary containment, closed at all times and properly labeled with full chemical name(s) and the word "USED"?** *Flasks and/or media collections containers must be clearly labeled to indicate their contents so those responding to spills will know what has spilled.*				Chemical collection containers should all be labeled with the full chemical name and no abbreviations. Once a collection container is full, or has not been added to recently, the container should be tagged with a green chemical collection tag for EHS to pick up.
6	**Does the lab properly dispose of empty chemical containers.** *Containers which held p-listed chemicals are regulated as hazardous waste and should be tagged with a green chemical collection tag for EHS to pickup. For a complete list of p-listed chemicals, contact EHS at (402) 559-6356.*				Most empty chemical containers can be triple rinsed, labels defaced and either recycled (plastic and metal) or thrown in the garbage (glass). Containers which held p-listed chemicals are regulated as hazardous waste (e.g. Sodium azide, Osmium tetroxide). Please tag empty, unrinsed p-listed chemical containers with a green chemical collection tag for EHS to pick up.
7	**Does the lab properly dispose of other potential regulated items?** (i.e. aerosol cans, batteries, lead autoclave tape, and hand sanitizer)				Regulated items must be tagged with the green chemical collection tag and picked up by EHS staff. For additional information on regulated waste, please contact EHS at (402) 559-6356.
8	**Does the lab have mercury thermometers?** *Mercury affects the central nervous system and with prolonged exposure, can cause brain damage. It is recommended that all labs replace mercury thermometers with alcohol thermometers.*				Elemental mercury spills account for approximately 80% of the spills in which EHS staff respond to on campus. Elemental mercury is somewhat volatile and is readily absorbed via the respiratory tract and through skin. It is recommended that all labs replace mercury thermometers with alcohol thermometers.
9	**Does the lab ship hazardous materials or dangerous goods? (i.e. biological agents, patient/animal specimens, dry ice, chemicals)** *All employees who ship hazardous materials or dangerous goods, which includes dry ice, Category A Infectious Substances affecting humans and/or animals, Category B Infectious Substances (biological substances), patient specimens (except human or animal specimens) and cultures, shall follow regulatory requirements for the applicable mode of transportation (e.g., air, ground).*				Please reference UNMC Policy No. 2002: http://wiki.unmc.edu/index.php?title=Shipping_Hazardous_Materials The shipment of hazardous materials or dangerous goods is a serious matter that requires UNMC compliance with regulatory requirements. Employees shall meet the initial and recurrent training requirements prior to signing a shipper's declaration or authorizing a hazardous material or dangerous goods package not requiring a shipper's declaration.
10	**Does the lab ship items out of the country?** *This includes testing kits, chemicals, radioactive material, equipment, hardware and materials including biological maters, technical information or data and/or software/code.*				If you are sharing, shipping, transmitting, or transferring goods; technology (technical information and data); software/code (commercial or custom) to a foreign national in the U.S. or a foreign individual/entity or country outside of the U.S., you may need an Export Control Review. Please contact Marsha Morien at (402) 559-4518 for assistance.