Concentrations of Particulate Matter from Wildland Fires

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Abstract

Wildland fires lead to emissions of particulate matter, which is composed of small particles and liquids, into the atmosphere. Research regarding the emission of particulate matter after a fire was conducted through a meta analysis of papers studying the concentrations of PM_{10} and $PM_{2.5}$ after a burn. $PM_{2.5}$ in particular can be a risk to human health and so it is important to measure the levels present after a fire has occurred. PM concentrations were compiled to find a total average concentration, along with average concentrations based on whether the plot was subject to mechanical chipping, whether emissions were measured in the perimeter or interior of a burn, or whether they were measured during the smoldering or nonsmoldering phase of a burn. Papers studying other factors that affect particulate matter at the time of a fire, such as weather, were also considered. Any studies conducted in the Lake States Consortium region, which is primarily composed of land bordering the Great Lakes, were considered separately in order to determine the research gaps present in the region. Preliminary results indicate that mean particulate matter concentrations ranged between198.1-3746.5 $\mu g/m^3$ during fires, several times the EPA recommended standards of 35 $\mu g/m^3$ for $PM_{2.5}$ and 150 $\mu g/m^3$ for PM_{10}, with the smoldering phase of fires causing the greatest concentrations of particulate matter to be released. Plots subjected to mechanical chipping produced the lowest concentration of particulate matter. The lack of articles that study particulate matter emissions specifically in the Lake States region indicates a need for further local research on the subject.

Introduction

Fire is an important disturbance in many ecosystems, but leads to the emissions of particulate matter. Particulate matter (PM) is composed of small particles and liquids which are released into the atmosphere

- PM is categorized as either inhalable coarse particulate matter (PM_{10}), or fine particulate matter ($PM_{2.5}$). Fine particulate matter is of particular concern to human health, because it is small enough to enter the lungs and even the circulation system of the body.
- The current 24-hour standards for particulate matter are 35 $\mu g/m^3$ for $PM_{2.5}$ and 150 $\mu g/m^3$ for PM_{10}.

The particulate matter that is released into the atmosphere because of a burn puts nearby communities and firefighters managing the fire at risk of inhaling higher concentrations than the recommended levels. Studying the concentration levels of different burns can provide an overall picture of the health risks. I reviewed articles that measured concentrations of particulate matter in the atmosphere after a burn and what factors affect these concentrations.

Lake States Fire Science Consortium

My mentored Independent Project research involved reviewing fire science literature for the Lake States Fire Science Consortium. The Lake States region includes parts of northern Wisconsin, Minnesota, and Michigan, and parts of Canada surrounding the Great Lakes. The Consortium has the goal of performing a gap analysis to see which areas of fire science are in need of further research in the Lake States region. Due to insufficient number of articles studying particulate matter in the Lake States region, I expanded my research to all articles studying particulate matter after woodland burns. I discuss the relevance of my findings to the Lake States Consortium region.

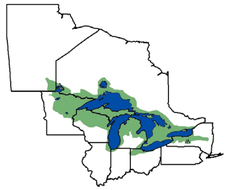

Figure 1. A map of the area covered under the Lake States Consortium Region.

Effects of Particulate Matter on Human Health

Exposure to $PM_{2.5}$ can cause adverse health effects such as changes in lung function that result in increases in respiratory and cardiovascular disorders, asthma being among one of the possibilities. Fine particles in the alveoli can lead to diseases such as emphysema, and these airborne particulates can sometimes carry toxic materials such as carcinogenic PAHs (Malilay, 1999).

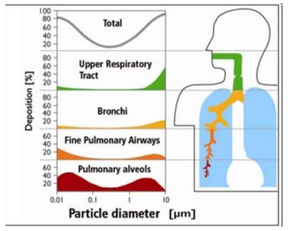

Figure 2. This figure shows the percentage of deposition of PM that reaches certain places in the respiratory system, based on diameter. Source: ICAO Information Paper CAEP-SG/ 20082-IP/05

Methods

- I identified any articles about particulate matter and recorded the concentrations of PM recorded in each study
- Total average emissions was calculated, along with the average emissions for chipped vs. nonchipped plots (interior and perimeter of the burns) and emissions for smoldering vs. nonsmoldering flames

Results

- The average concentration of emission of $PM_{2.5}$ from fires in all the data collected was found to be 1022.9 $\mu g/m^3$ but had a high standard deviation of 1414.7 $\mu g/m^3$

Table 1. This table provides an overview of that average concentrations and their standard deviations (in $\mu g/m^3$) for the different variables studied in the articles, along with the total average from all the measured concentrations from all articles.

	Averages ($\mu g/m^3$)	Standard Deviation ($\mu g/m^3$)	Number
Total	1022.9	1414.7	42
Nonsmoldering	3746.5	2150.2	6
Smoldering	508.3	290.2	6
Nonchipped (Perimeter)	519.9	238.8	8
Chipped (Perimeter)	198.1	71.7	8
Nonchipped (interior)	618.7	321.8	4
Chipped (interior)	460.3	147.3	4

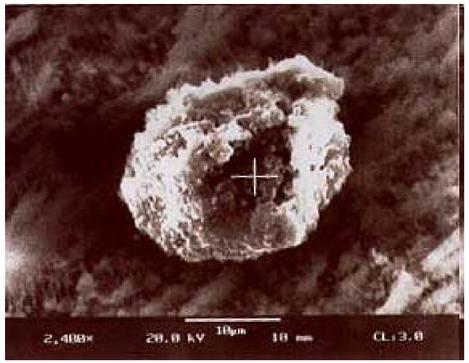

Figure 3. A microscopic view of particulate matter. Source: http://wwww.hartford.gov

Discussion

41 out of 42 measurements exceeded EPA's 24-hour standard for particulate matter

Methods employed for prescribed burns need to take into account which techniques cause lower emissions

Chipped plots produce less PM

Smoldering phases and perimeters of burn all experience lower emissions, so if humans must be exposed, these conditions produce lower health risks

Other factors to consider: types of vegetation

Grassland burns lead to lower emissions than woodland burns (Robinson et al, 2004).

Weather can also affect particulate matter

PM concentrations were found to be higher in weather classified as "muggy" or having high humidity (Wise, 2008).

All these factors need to be taken into account when conducting burns so that firefighters and nearby communities are exposed to as little particulate matter as possible

The lack of articles about PM emissions in the Lake States Region indicates this is an area where further research could be done

The research showing that grasslands produce less PM than woodlands when burned could be relevant to possible research to be done in the Lake States region, since it contains both habitat types

The same could be same for weather and PM concentrations, because the region experiences humid weather as well

References

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