Concentrations of Particulate Matter from Wildland Fires

Anum Samdani1, Jessica R. Miesel2,3, David J. Mladenoff1, and P. Charles Goebel2,3
1Department of Forestry and Wildlife Ecology, University of Wisconsin-Madison, 2Lake States Fire Science Consortium, and 3Ohio Agricultural Research and Development Center, The Ohio State University

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 PM10 and PM2.5 after a burn. PM2.5 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 are not the focus of the research, 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 range between 115 to 17,445 μg/m3 during fires, several times the EPA recommended standards of 35 μg/m3 for PM10 and 150 μg/m3 for PM2.5 with the smoldering phase of fires causing the greatest concentrations of particulate matter to be released. Flots produced after 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 future 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 (PM10), or fine particulate matter (PM2.5).

• 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 μg/m3 for PM10 and 150 μg/m3 for PM2.5.

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. However, reviewed articles that measured concentrations of particulate matter in the atmosphere after a burn and what factors affect these concentrations.

Effects of Particulate Matter on Human Health

Exposure to PM2.5 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).

Table 1: This table provides an overview of the average concentrations and their standard deviations (in μg/m3) for the different values studied in the articles, along with the total average from all the measured concentrations from all articles.

<table>
<thead>
<tr>
<th></th>
<th>Averages (μg/m3)</th>
<th>Standard Deviation (μg/m3)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1022.9</td>
<td>1414.7</td>
<td>42</td>
</tr>
<tr>
<td>Nonsmoldering</td>
<td>3746.5</td>
<td>2150.2</td>
<td>6</td>
</tr>
<tr>
<td>Smoldering</td>
<td>508.3</td>
<td>290.2</td>
<td>6</td>
</tr>
<tr>
<td>Nonchipped (Perimeter)</td>
<td>519.9</td>
<td>238.8</td>
<td>8</td>
</tr>
<tr>
<td>Chipped (Perimeter)</td>
<td>196.1</td>
<td>71.7</td>
<td>8</td>
</tr>
<tr>
<td>Nonchipped (Interior)</td>
<td>618.7</td>
<td>321.8</td>
<td>4</td>
</tr>
<tr>
<td>Chipped (Interior)</td>
<td>460.3</td>
<td>147.3</td>
<td>4</td>
</tr>
</tbody>
</table>

Methods

• 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 PM2.5 from fires in all the data collected was found to be 1022.9 μg/m3 but had a high standard deviation of 1414.7 μg/m3.

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


