Exposure to Particulate Matter in Toronto’s Subway

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Introduction

The subway is a convenient and effective way to travel for most urban commuters. However, due to limited ventilation and high traffic, commuters are exposed to elevated concentration of some air pollutants for an hour or more everyday. This project evaluated the extent to which the mechanical wear and friction occurs during braking contributes to airborne particulate matter concentrations in the Toronto subway system.

Methodology

Platform volumes and ventilation condition were investigated particularly at four Toronto subway stations (Queen’s Park, Museum, Spadina and Bayview). The necessary wear of the material information in Toronto subway braking system was provided by Toronto Transit Commission (TTC). The expected concentrations of airborne particles on these four platforms were then evaluated and compared with the PM 2.5 results from actual measurement taken from corresponding platforms.

Platform Volume

The size and shape of platforms vary from station to station, but the general length of each platform is about 500 feet (152.4m). Figure 1 shows the cross section of the simulated platform at Bayview Station. The platform volume is the multiplication product of its cross section area and length. Same method was applied for the estimation in Table 1.

Average Production Rate

In subway braking system, brake shoes are known as the friction material having a wear of 1.5 inches (3.810 cm) every 9 months. Since the material formulation the brake shoe is highly confidential, its density was estimated according to the ingredient list in its MSDS document and the reference to railroad brake shoe material, [2]. The wear from the brake shoe was calculated in unit of ton/year as shown in Table 2.

Table 1 Estimated Volume for investigated platforms

<table>
<thead>
<tr>
<th>Platform Volume (m^3)</th>
<th>Queen’s Park</th>
<th>Museum</th>
<th>Spadina</th>
<th>Bayview</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.072 x 10^3</td>
<td>9.998 x 10^2</td>
<td>1.052 x 10^3</td>
<td>1.231 x 10^4</td>
<td></td>
</tr>
</tbody>
</table>

The average concentration of particulate matters on the platform is a function of average production rate Q (μg/(m^2 * s)). To simplify the estimation, the production rate was set to be the division product of wear and platform volume and was considered to be constant.

Table 3 Average Production rate on investigated platforms

<table>
<thead>
<tr>
<th>Platform</th>
<th>Queen’s Park</th>
<th>Museum</th>
<th>Spadina</th>
<th>Bayview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q (μg/(m^2 * s))</td>
<td>0.8511</td>
<td>0.9123</td>
<td>0.8668</td>
<td>0.7410</td>
</tr>
</tbody>
</table>

Table 3 was calculated based on the assumptions below:

• 76% of braking process takes place at platforms
• Material lost from braking system are equivalent at each station
• Brake shoes are the only source that contributes to production rate

Elimination Rate

After braking, the concentration decreases exponentially due to ventilation and the decreasing rate was quantified in terms of elimination rate λ (s^-1) [2]. Graph 1, 2 and 3 show each elimination phase on the platform at Bayview Station. The elimination rate λ for this station was obtained by averaging these three corresponding λ from each graph. Same method was used for estimation in Table 4.

Table 4 Elimination rate on investigated platforms

<table>
<thead>
<tr>
<th>Platform</th>
<th>Queen’s Park</th>
<th>Museum</th>
<th>Spadina</th>
<th>Bayview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elimination Rate (s^-1)</td>
<td>0.006854</td>
<td>0.008450</td>
<td>0.008600</td>
<td>0.009181</td>
</tr>
</tbody>
</table>

Acknowledgments

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References