ROAD DUST

PM$_{10}$ and Health Effects
CONTENTS

• introduction
• ambient monitoring in Northland
• modelled vs measured
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• where to from here?
Unsealed roads

~ 31,000 km of unsealed roads in New Zealand
Unsealed roads
~ 3,500km in Northland
adverse effects

- safety and health hazards for road users and those living or working nearby
- economic costs from reduced productivity of land, crops and livestock,
- increased road and vehicle maintenance costs
- contaminated drinking water
- soiling of houses and property, reduced amenity
- health effects

Photo credit: Lois Williams, RNZ
Fed up Northlanders take dusty road fight to Prime Minister

Pipiwi residents say dust whipped up by logging trucks is making them sick, and driving dangerous.
Source: 1NEWS5
PM$_{10}$ monitoring in Northland (NRC and FNDC)
% valid data

- 91% PM$_{10}$ (hourly)
- 95% PM$_{10}$ (daily)
- 96% Wind speed/direction (hourly)
Daily PM$_{10}$ Levels

Pipiwai Rd 1 Jun 2017 - 31 May 2018

NES PM$_{10}$ = 50 µg/m$^3$
### Monitoring results

#### 24-hour PM$_{10}$

1 Jun 2017 – 31 May 2018

<table>
<thead>
<tr>
<th></th>
<th>Concentration (µg/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum</strong></td>
<td>164</td>
</tr>
<tr>
<td><strong>Second highest</strong></td>
<td>127</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>Mean (annual average)</strong></td>
<td>20</td>
</tr>
<tr>
<td><strong>Standard deviation</strong></td>
<td>22</td>
</tr>
<tr>
<td><strong>95$^{th}$ percentile</strong></td>
<td>64</td>
</tr>
<tr>
<td><strong>70$^{th}$ percentile</strong></td>
<td>19</td>
</tr>
<tr>
<td><strong>Number of days &gt; 50 µg/m$^3$</strong></td>
<td>28 (8%)</td>
</tr>
</tbody>
</table>
### Monitoring Results

#### 1-hour PM$_{10}$

**1 Jun 2017 – 31 May 2018**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Concentration ($\mu g/m^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>1,101</td>
</tr>
<tr>
<td>Minimum</td>
<td>0</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>44</td>
</tr>
<tr>
<td>95$^{th}$ percentile</td>
<td>200</td>
</tr>
<tr>
<td>95$^{th}$ percentile</td>
<td>69</td>
</tr>
<tr>
<td>70$^{th}$ percentile</td>
<td>18</td>
</tr>
<tr>
<td>Number of hours &gt; 150 $\mu g/m^3$</td>
<td>124 (1.4%)</td>
</tr>
</tbody>
</table>
NES for PM$_{10}$ exceedances
1 Jun 17 – 31 May 18
$PM_{10}$ highest on days when rainfall <1mm per day
PM$_{10}$ highest on days when there are 40, or more, trucks per day.
modelled vs measured

US EPA emission factors + NZTA screening dispersion model = Pipiwai monitoring?
\[ EF = k \left( \frac{s}{12} \right)^a \left( \frac{W}{3} \right)^b \]

Where:
- \( k \), \( a \) and \( b \) are (US EPA) constants
- \( s \) = silt content
- \( W \) = mean vehicle weight
Dispersion

24 hour $PM_{10}$ ($\mu g/m^3$) = $0.325 \exp(-0.3d^{0.5}) \times \left(\frac{AADT}{24}\right) \times EF \times 0.5$

Where:

d = distance from road

EF = (US EPA) emission factor

AADT = annual average daily traffic
Modelled vs measured

- Preliminary emission factor
- Model significantly underestimates maximum and average
Modelled vs measured

- “Calibrated” emission factor
- Average modelled PM$_{10}$ = average measured PM$_{10}$
- Model still underestimates maximum PM$_{10}$
## Modelled vs Measured

Annual emission factor estimated based on days of rain

<table>
<thead>
<tr>
<th>Road</th>
<th>AADT (heavy)</th>
<th>(Calibrated) Modelled annual PM$_{10}$</th>
<th>Background annual PM$_{10}$</th>
<th>Modelled annual PM$_{10}$ (including background)</th>
<th>Measured annual PM$_{10}$ Pipiwi Road</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vehicles/day</td>
<td>(µg/m$^3$)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipiwi Road</td>
<td>32</td>
<td>9</td>
<td>9</td>
<td>18</td>
<td>20 (measured)</td>
</tr>
</tbody>
</table>
health effects of road dust?
current research: PM

Causative

- exacerbation of asthma
- cardiovascular morbidity
- cardiovascular mortality
- infant mortality
- lung cancer

Source: Review of evidence on health aspects of air pollution (WHO, 2013) [www.euro.who.int]
current research: PM

Associative

- artherosclerosis
- adverse birth outcomes
- childhood respiratory disease
- cognitive impairment
- neurological disorders
- diabetes
- systemic inflammation

Source: Review of evidence on health aspects of air pollution (WHO, 2013) [www.euro.who.int]
Emerging

- Focus on PM$_{2.5}$ monitoring has made research into PM$_{10-2.5}$ fraction difficult
- But, more evidence emerging of effects independent to PM$_{2.5}$ for example:
  - Association with childhood asthma (Keet et al 2017)
  - Association with cardiovascular admissions (Powell et al 2015)
  - Association with mortality (Chen et al 2019)
Limited specific studies on road dust

- Studies have confirmed significant association between non-accidental mortality and daily concentration of road dust in Sweden and Canada (Meister et al., 2012, Hong et al., 2017)
- Local factors could be significantly different (spring melt)
- Hong et al., 2017 conclude that acute and chronic health effects remain unclear, which supports the maintenance of PM$_{10}$ monitoring networks
Health effects

For this study:

• Assume all PM$_{10}$ is equal.
• Consistent with WHO and NZ guidance.
• Consistent with previous work (Bluett et al., 2016)
  • Chronic exposure response functions from Kuschel et al., 2012
• Investigate road dust specific effects:
  • Acute exposure response function from Hong et al., 2017
Assumptions and data:

- Calibrated annual emission factor of 223 g per truck VKT
- NZTA screening tool dispersion model
- Distance from houses to road 30m
- FNDC data:
  - Truck VKT for each road
  - Number of houses close to each road
chronic

- non-accidental mortality 7% per 10 µg/m³ annual PM$_{10}$ (Kuschel, et al., 2012)
- applied to all unsealed roads
- estimate 6 people every 10 years in rural Northland (only)
- $2.74$ million per annum (mortality & morbidity)
Indicative assessment only based on dose response functions from a single Canadian study:

• non-accidental mortality 4.7% per 12 µg/m³ daily PM$_{10}$ (Hong et al., 2017)
• applied to all days of Pipiwai monitoring
• 52% of chronic estimate
• Based on measurements at one site only
• \( \text{PM}_{10} \) vs trucks might be different at sites with different meteorology, traffic profile, speed, roading materials…
• Sensitive to assumptions e.g. average distance of houses to road, silt content of road surface, dose response relationships
Costed

- mortality & morbidity PM$_{10}$

Not Costed

- accidents caused by lack of road visibility
- reduced productivity of land, crops and livestock,
- increased road and vehicle maintenance
- contamination of drinking water
- reduced amenity due to soiling of houses and property
Recommendations

- More monitoring
- Improve and extend exposure assessment
- Further investigation of dispersion modelling results and emission factors
- More thorough economic assessment
The surprising stat from driving in the country

DUSTY ROADS KILL

The numbers

$3m cost to the health sector
60% of Northland roads, excluding highways, are unsealed

27 times the national environment standards were breached in Northland

A study has estimated that one Northlander dies every two years due to dust generated from unsealed roads.

"Northland Public Health have been actively advocating to address dust generated by heavy vehicular (forestry) movements on rural unsealed roads, especially along the unsealed roads with higher population density," Shetty said.

Northland DHB was actively working with community groups affected by unsealed roads, he said, and had made several submissions to the territorial authorities in the region in recent years.

Dall said that, in 2014, Northland Regional Transport Committee which included representatives from Northland councils and the Zealnd Transport Agency – proved the Regional Dust Unsealed Roads Mitigation Project.

"Under this framework, the regional council monitors the unsealed roads and provides monitoring results to the relevant district councils to help them prioritise sites for dust mitigation measures."

Dall said the RDC carried out the monitoring every summer, when dust issues were typically at their peak, and had monitored a total of 32 roads since 2013.

He said the RDC consulted with district councils to identify potential monitoring sites and contacted nearby property owners to find out if they were prepared to have a dust monitor deployed on their property and provide the power supply required to operate the monitor.

And Shetty, public health strategist at the Northland District Health Board, said they looked forward to seeing the results of the next round of monitoring.
thank you

Louise Wickham & Jayne Metcalfe