Effects of Vegetation on Traffic-Related Particulate Matter

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Introduction

Traffic-related air pollution has been shown to have detrimental effects on health and the environment. One of the components of such pollution is particulate matter (PM), which increases the risk of cardiopulmonary symptoms and diseases when inhaled[1].

While technological improvements and stricter emission regulations have in recent years contributed to a decrease in transport-related PM emissions per vehicle, this decrease has been offset by an increase in the number of vehicles, many of which are diesel powered and emit a higher amount of particulate matter than gasoline vehicles, as well as an increase in the number of short trips and traffic congestion[1,2,3].

Since the amount of traffic has steadily been increasing, mitigation measures to combat traffic-related air pollution have been researched. As plants are already known for their carbon sequestration properties, research has been put forth in order to investigate other potential amenities they might offer.

This research focuses on the effects vegetation barriers have on particulate matter emitted by road traffic. Through a comparison in PM distribution with and without a vegetation barrier, as well as a comparison between two different kinds of barriers, an attempt was made to determine the effectiveness of these barriers, and potentially offer a suggestion to city officials in an attempt to improve near-road air quality in Reykjavik.

Particulate Matter

Particulate matter (PM) is a term used for a complex mixture of liquid droplets and solid particles suspended in the atmosphere such as dust, soot, black smoke, volcanic ash and the like[3,4].

Particulate matter can be natural or anthropogenic in origin and is usually classified by size into:

- Coarse particles: 2.5–10 µm in diameter ($PM_{2.5} – PM_{10}$)
- Fine particles: smaller than 2.5 µm ($PM_{2.5}$)
- Ultrafine particles: smaller than 100 nm ($PM_{0.1}$), or smaller than 1 µm (PM_1); depending on definition

Particulate Matter in Iceland

Iceland's unique landscape provides for several natural sources of particulate matter. These include sandy deserts which cover approximately 20% of Iceland, glaciers which create PM as the ice grinds over subglacial sediment and bedrock, as well as Iceland's numerous active volcanoes whose eruptions can be a massive source of particulate matter of various sizes[5,6].

Iceland is one of the countries with the highest number of motor vehicles per capita (almost 750 vehicles per 1000 people between 2009 – 2013) [7] and according to the Environment Agency of

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Iceland (Umhverfisstofnun, or UST), road traffic and fishing boats are the highest source of local, anthropogenic air pollution which includes particulate matter. The large number of vehicles per capita in Iceland does not only contribute to PM emissions through the burning of fossil fuel but also through the use of studded tires which release PM through asphalt erosion (Figure 1).

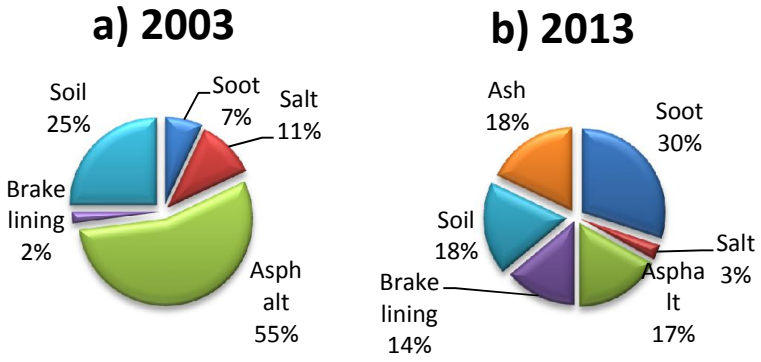

Figure 1- Composition of particulate matter (coarse and fine) represented as average percentages from the samples taken during the winter in Iceland in (a) 2003 and (b) 2013 (Skuladottir et al., 2003; EFLA, 2013)

Effects of Vegetation on Particulate Matter

Plants can act as barriers by intercepting airborne PM, and they can also absorb PM, mainly through leaf stomata. Due to overall greater leaf surface and more turbulent mixing of air, trees are more efficient in capturing pollutants than shorter vegetation[8]. Conifers seem to have a higher trapping efficiency than deciduous trees due to finer and more complex structure of their foliage. Amongst broadleaved trees, it is the ones with coarse and hairy leaves that are better at trapping PM[9,10].

Results of the Research

This research tested the effects of two different types of barriers, one coniferous and one mixed, on the PM emitted by road traffic. Both barriers are on the side of the Miklabraut road in Reykjavik, Iceland. It should be noted that the coniferous barrier tested in this research was not in good health and the trees are missing a big portion of their foliage. The mixed barrier was composed of healthy, luscious plants, both coniferous and deciduous, of various sizes including very tall trees and shrubs.

Particles were collected with two identical TSI Optical Particle Sizers (model 3330) and the size of collected particles ranged from 0.3 – 10 µm.

Contrary to the previous research on the similar topic, the coniferous barrier appeared ineffective in filtering the particles. This seems to indicate that it is the foliage that plays the most critical role in PM capture and absorption, rather than the bark and bare branches (Figure 2a).

The mixed barrier, however, showed some interesting results. The smallest fraction (particles up to 0.6 µm) showed a drastic decrease behind the vegetation barrier compared to the samples taken without a barrier on the same location (Figure 2b). The results for larger particles were either too inconsistent or the particle count was too low to reach any reliable conclusion.

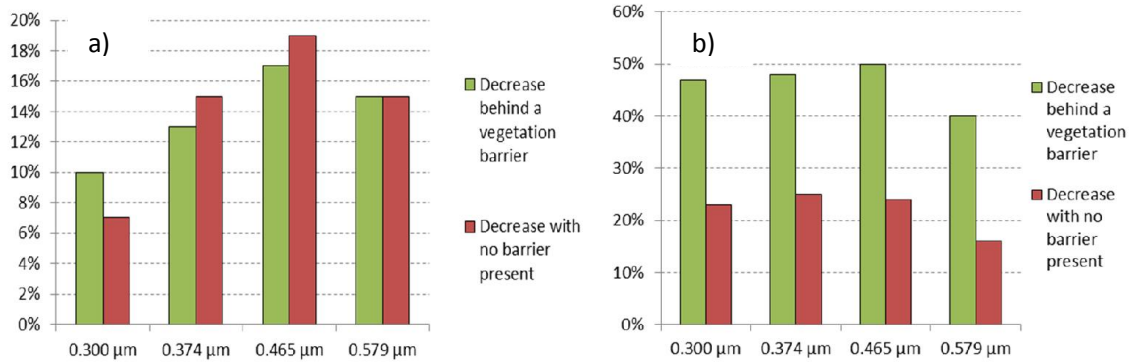

Figure 2 - Decrease in particle concentration between the instrument placed next to the road and the instrument placed 25 m perpendicular to the road as measured (a) on 22.05.2014 and 23.05.2014. at the 365 Media building location and (b) 31.07.2014 and 01.08.2014. at Location 2 (Klambratún).

Conclusion

After analyzing the results, the ineffectiveness of leafless conifers was quite striking and the inclusion of a barrier composed of healthy conifers would have been invaluable. However, the lack of foliage and the subsequent ineffectiveness of the barrier did serve to strengthen the conclusions from previous research on the topic, that it is the leaves and needles of trees that play the biggest role in PM capture, rather than bare twigs and bark.

The mixed barrier, however, proved to be very effective in filtering particles smaller than 0.6 µm. The exact reason behind the effectiveness of the mixed barrier on ultrafine particles should be researched more. Plant health seems to be one of the prerequisites of an effective barrier. A comparison of a healthy coniferous, mixed and deciduous barrier would help identify the best composition in order to maximize its effectiveness.

As ultrafine particles are the ones that are most detrimental to health, a next-to-the-road vegetation barrier that would prevent at least this fraction from spreading far from its source, and impacting those living or working close to busy roads, seems like a worthwhile investment.

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