Traffic-Related Ultrafine Particle Exposure in Boston, Massachusetts

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Projection: NAD 1983 Massachusetts State Plane Mainland FIPS 2001

Data Sources: MassGIS, Tufts University

Introduction

Exposure to traffic-generated ultrafine particles (UFP; <100 nm diameter; Fig. 1) may be associated with cardiovascular disease; however, to date relatively little work has been done to quantify the risks due to challenges of accurately predicting exposure. UFP are easily transported deep within the lungs, and can pass through into the blood stream, increasing their potential for lasting damage.[1] UFP exposure levels can vary greatly over space, with some of the highest concentrations found near highways and major roadways.[2]

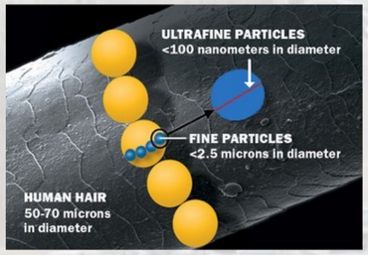


Fig. 1: Size comparison of UFP. Image from: http://now.tufts.edu/articles/big-road-blues-pollution-highways.

Objectives

The objectives of this project were to: (1) use measurements of particle number concentration (PNC; a proxy for UFP) at various spatial and temporal scales within Boston to see how PNC varies by location, and (2) determine which populations within the city are most vulnerable to exposure and thus its harmful effects. During the course of this project, the following hypotheses were tested:

H1: People living closest to highways and major roadways (road classes 1-3, which are classified as interstates and principal arterials) will have the highest ambient PNC exposure, while those living furthest from these roads will have the lowest ambient exposure.

H2: PNC levels will noticeably change with the seasons, but the trend of H1 will still hold true.

Methodology

One-second interval PNC data was used for this project and was collected from the Tufts University mobile air monitoring laboratory (Fig. 2) between December 2011 and March 2013 along a prescribed route within the Boston, MA study area. Field data was quality controlled for a variety of factors, described in detail elsewhere.[3] Analysis of this data was done by mapping PNC over various data layers obtained from the Massachusetts Office of Geographic Information (MassGIS) website.[4] These layers included, but were not limited to: land use, roadways, bus routes, and commuter train lines.

Average PNC, annual as well as seasonal, was used to analyze the ambient UFP exposure of residents within the study area. The exposure areas considered were confined to residential areas, as defined by MassGIS, within 100 m of the monitoring route. These areas were divided into two categories: (1) those within 100 m of a major roadway, and (2) those greater than 100 m from a major roadway. Additionally, annual PNC was averaged over various distances away from major roadways. These were categorized as: 0-50 m, 50-100 m, 100-200 m, 200-400 m, and 400-800 m. This analysis was used to determine how PNC changed with increasing distance away from the major roadways.

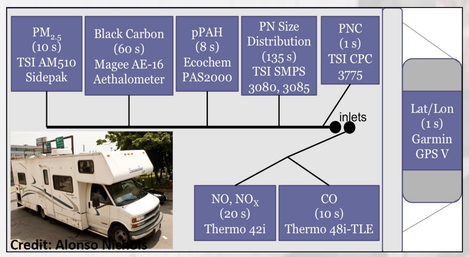


Fig. 2: Mobile monitoring vehicle with equipment diagram.

Results

Seasonal trends in PNC were seen throughout Boston, with summer and winter being the seasons with the lowest and highest average concentration, respectively (Fig. 3-6). Average and median PNC for each of the seasons is listed with the figures. Residential areas located within 100 m of a major roadway had only slightly elevated annual average PNC as compared to residential areas further away (56,000 particles/cm^3 versus 55,000 particles/cm^3, respectively). The difference was more pronounced when compared by season (Table 1).

Table 1: Average PNC by season for residents within 100 m of a major roadway and residents >100 m from a major roadway.

Season	Residents <100 m of Major Roadway	Residents >100 m from Major Roadway
Winter	85,000 particles/cm^3	87,000 particles/cm^3
Spring	46,000 particles/cm^3	31,000 particles/cm^3
Summer	30,000 particles/cm^3	22,000 particles/cm^3
Fall	41,000 particles/cm^3	34,000 particles/cm^3

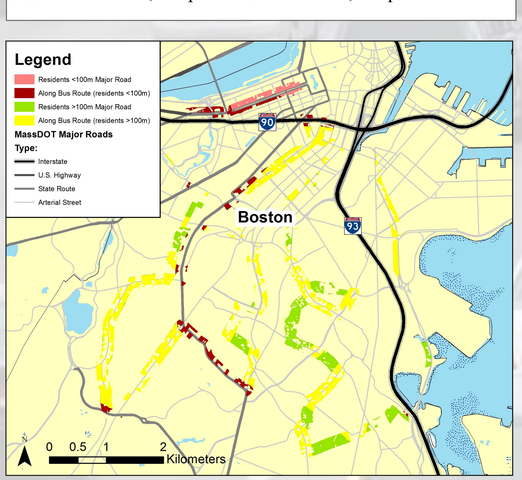


Fig. 7: Residential locations along the mobile monitoring route coded by proximity to major roadways and bus routes within the city.

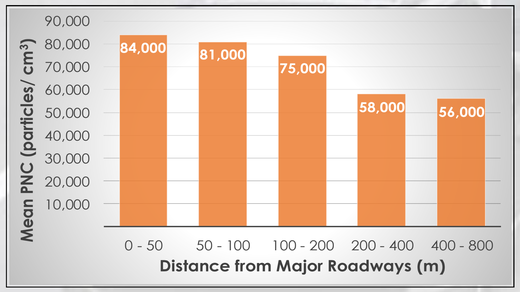
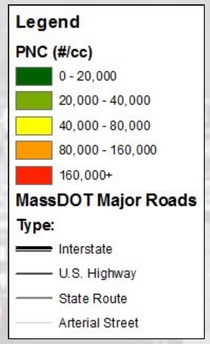


Fig. 8: Annual average PNC based on proximity to major roadways.



Further analysis was done to see what additional factors, if any, may be contributing to residents' UFP exposure. This analysis showed that ~70% of all residents live within 100 m of a bus route, a commuter train line, or both. Figure 7 highlights this statistic for the bus routes.

A final analysis was done to determine if there was a relationship between PNC and distance from major roadways. Figure 8 shows the results from this analysis. As the distance from major roadways increases, PNC decreases. The highest PNC levels are found within 0-50 m of the major roadways. After at least 200 m away from the major roadways, PNC appears to taper off, but still continues to show a decreasing trend.

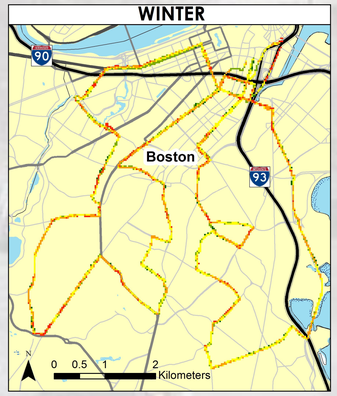


Fig. 3: Winter avg. PNC = 93,000 particles/cm^3; median PNC = 37,000 particles/cm^3.

Fig. 4: Spring avg. PNC = 36,000 particles/cm^3; median PNC = 26,000 particles/cm^3.

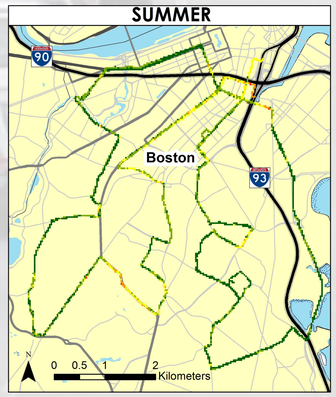


Fig. 5: Summer avg. PNC = 28,000 particles/cm^3; median PNC = 18,000 particles/cm^3.

Fig. 6: Fall avg. PNC = 40,000 particles/cm^3; median PNC = 25,000 particles/cm^3.

Conclusions

1. People living closest to the highways and major roadways (<100 m) are exposed to the highest ambient PNC concentrations, except during winter where those people living >100 m from major roadways have nearly the same exposure as those living <100 m from major roadways. Ambient PNC concentrations decrease with increasing distance away from major roadways.
2. Ambient PNC levels change seasonally, yet still behave as described in Conclusion 1 for three out of four seasons. Winter showed only slightly higher PNC levels for the residential areas >100 m from a major roadway.

References

1. Geiser et al., 2005, Env. Health Perspectives, 113(11), 1555-1560.
2. HEI Review Panel, 2013, HEI Perspectives 3.
3. Padró-Martínez et al., 2012, Atmos. Env, 61, 253-264.
4. MassGIS (http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/).

Acknowledgements

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