Environmental Injustice: Traffic Related Air Pollution in Chelsea, Mass

Introduction

With the urbanization and industrialization that has occurred over the past century, many areas throughout the world have experienced air pollution issues. Due to emissions from motor vehicles, highways and their surrounding areas tend to have high concentrations of certain air pollutants. Exposure to many air pollutants is known to cause a variety of illnesses, including cardiovascular disease and obesity.[1,2]

Nitrogen Oxides (NOx) are a specific type of air pollutants that are emitted by automobiles. The term 'NOx' encompasses nitrogen oxide (NO) and nitrogen dioxide (NO_2). NOx is correlated with other pollutants related to traffic, such as NO_2 and $PM_{2.5}$, which are both EPA criteria pollutants. Therefore, NOx concentration measurements can serve as a proxy for other types of traffic related air pollution.

This study focuses on NOx levels in Chelsea, MA, which is located in the Boston area (Figure 1). The purpose of the study was to determine where high levels of NOx concentrations exist and to analyze what populations are exposed to them. Specifically, Environmental Justice (EJ) populations were studied. According to MassGIS, an EJ population has one or a combination of the following characteristics: greater than 25% minority, median income less than 65% Massachusetts median income (low income), and/or greater than 25% English isolation.[3] Also, land use data was used to analyze whether or not the highest NOx levels occurred in high-density residential areas.

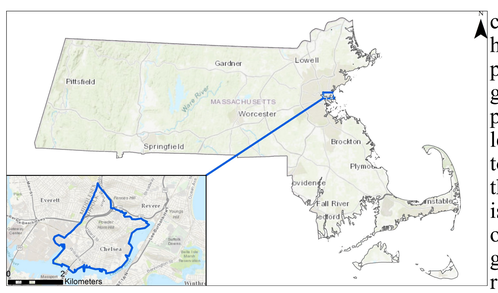

Figure 1: Location of Chelsea in Massachusetts

Historically, marginalized communities are exposed to higher levels of environmental pollutants than non-marginalized groups. In the case of air pollution, experiencing a higher level of exposure is likely to lead to higher levels of sickness in these populations. This disparity is reason to investigate the extent of higher exposure marginalized groups receive. In this study, at-risk areas within Chelsea that require intervention will be identified by combining air pollution data with census and land use data.

Data and Methodology

NOx Air Pollution data was collected by Professor John Durant's research team in the Civil and Environmental Engineering Department at Tufts University. A mobile air quality monitoring system was driven around a mobile monitoring route at various times and dates from 2013-2015. The EJ Populations data and land use data were downloaded from MassGIS. The EJ populations data was derived from Census 2010 data by MassGIS.

To determine what populations are impacted by high levels of NOx, the interpolated NOx data from the mobile monitoring route was combined with Environmental Justice populations and land use data by using the following methods:

First, the IDW interpolation tool was used to interpolate the NOx concentration data from the mobile monitoring route. The resulting raster was inputted through the focal statistics tool in order to smooth the data and remove background noise. Next, the raster was reclassified based on quantiles into a high, moderate, and low category of NOx concentration. Then, the resulting raster was converted to a polygon shapefile using the Raster to Polygon tool. This layer was then clipped by the boundary of Chelsea (Figure 3). A new layer was made by selecting only "High Density Residential" and "Multi-family Residential" land descriptions from the land use layer. This layer was also clipped to the boundary of Chelsea (Figure 6).

The NOx concentration polygons layer was then intersected with the EJ populations layer using the Overlay—Intersection tool, and then a new layer was created by selecting the polygons that had high NOx concentrations (Figure 5). The NOx polygons layer was also intersected with the residential land use layer, and a new layer was created by selecting the polygons that had high NOx concentrations (Figure 7). Finally, the high NOx and EJ layer was intersected with the high NOx and residential areas layer to create Figure 8.

Results

Figure 2: Mobile Monitoring Route in Chelsea, MA

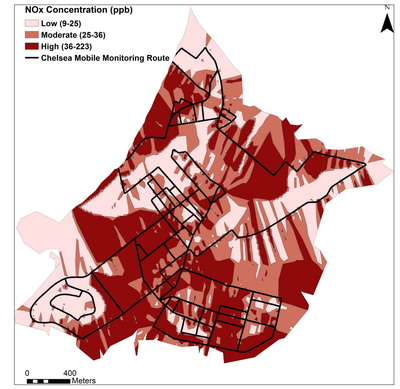

Figure 3: Interpolated NOx Concentrations

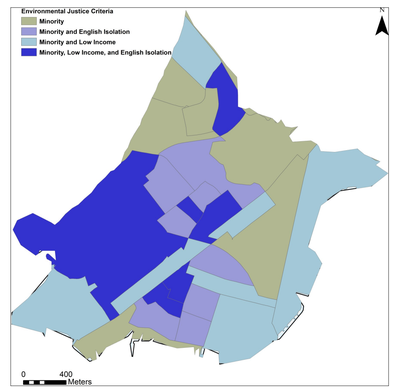

Figure 4: Environmental Justice Populations

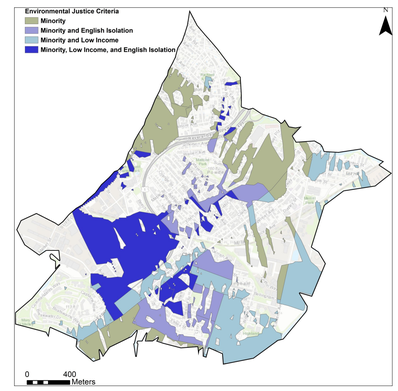

Figure 5: Environmental Justice Populations Exposed to High NOx Concentrations

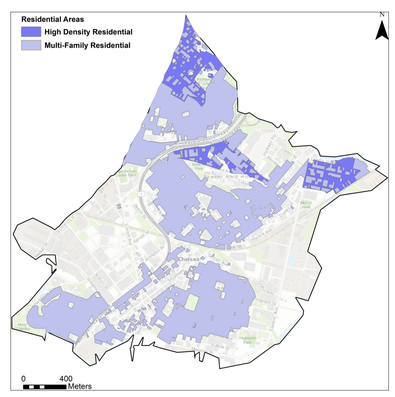

Figure 6: Residential Areas (High Density and Multi-family)

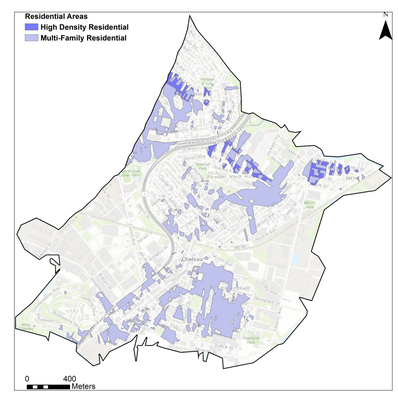

Figure 7: Residential Areas Exposed to High NOx Concentrations

Cartographer: Lauren Quickel
CEE-187 Introduction to GIS
December 7, 2017
Projection: NAD 1983 StatePlane Massachusetts Mainland FIPS 2001

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Discussion

The results of the interpolation of the NOx data collected along the mobile monitoring route can be observed in Figure 3. Figure 4 shows the locations of EJ Populations, and Figure 6 shows the locations of High Density and Multi-family Residential areas. In Figure 5, the areas that are exposed to high NOx levels are shown and divided into EJ categories. The large dark purple are indicates the area where there are high percentages of minority, low-income, and English Isolated communities. This large area demonstrates the notion that marginalized people are exposed to high levels of air pollution. However, in Figure 7, which shows the areas that are exposed to high levels of NOx and have high residential densities, it can be observed that many of the areas with high NOx concentrations are not areas with a lot of people living in them. Finally, Figure 8 shows the areas in Chelsea that are exposed to high NOx concentrations, have a high residential density, and house EJ populations. The areas shown in Figure 8 identify at-risk populations of marginalized people who are exposed to high levels of NOx and other air pollutants. Because of the correlation between air pollution and cardiovascular health, an intervention in this area is recommended.

In future research, it would be beneficial to spatially analyze the correlations between air pollution, EJ populations, and health outcomes. Also, similar data exists for a mobile monitoring route in Boston, and it would be interesting to compare Boston and Chelsea results. There are many limitations of this study. For example, the interpolation of the NOx data is not a perfect representation of the air pollution level in the areas between the mobile monitoring route data. The areas far away from the route are subject to high levels of uncertainty. Also, the high category of NOx concentration is not necessarily the level of concentration that is dangerous to human health, but since NOx correlates with other air pollutants, the high NOx areas likely have levels of NO_2, $PM_{2.5}$, and other traffic related air pollutants.

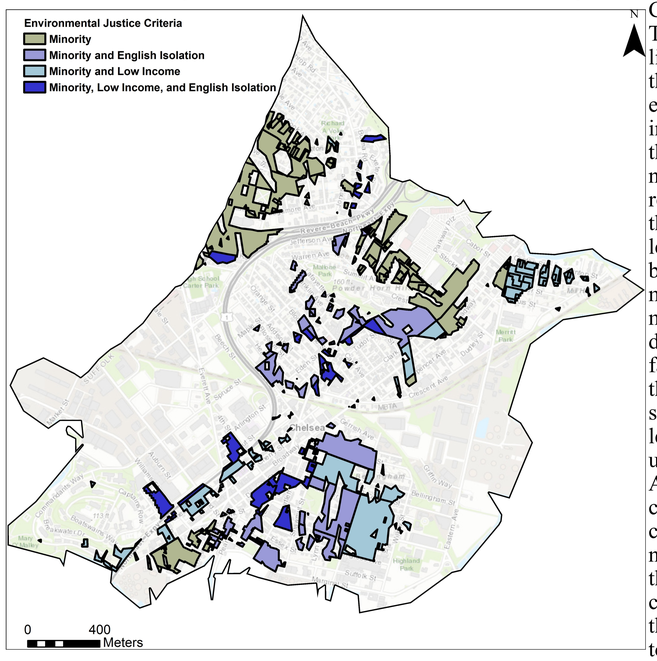

Figure 8: High-Density Residential Environmental Justice Populations Exposed to High NOx Concentrations

The people who live in areas with high levels of air pollution are at a greater risk for contracting a cardiovascular disease. For this reason, it is important to monitor air pollution and to prevent marginalized communities from being disproportionately exposed.

References

1. Brugge, D., Lane, K., Padró-Martínez, L. T., Stewart, A., Hoesterey, K., Weiss, D., … Mwamburi, M. (2013). Highway proximity associated with cardiovascular disease risk: the influence of individual-level confounders and exposure misclassification. *Environmental Healthn A Global Access Science Source*, *12*(1), 84. https://doi.org/10.1186/1476-069X-12-84

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4. Padró-Martínez, L. T., Patton, A. P., Trull, J. B., Zamore, W., Brugge, D., & Durant, J. L. (2012). Mobile monitoring of particle number concentration and other traffic-related air pollutants in a near-highway neighborhood over the course of a year. *Atmospheric Environment*, *61*, 253–264. https://doi.org/10.1016/j.atmosenv.2012.06.088