Assessing Particulate Pollution in the Østerbro District of Copenhagen

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ABSTRACT

Ultrafine particulate (UFP) pollution causes 500 premature deaths annually in Copenhagen, Denmark. This project, in conjunction with Miljøpunkt Østerbro, measured UFP, using a P-Trak Ultrafine Particle Counter, near various schools and a large park in Østerbro district, chosen because children are at the greatest risk of developing long term complications. Final measurements and analysis showed a strong correlation between the number of diesel engines and high concentrations of UFP, that UFP dissipates over distance, and noise barriers decrease the concentration in the immediate area. Using this data and additional observations, the team created a list of suggestions for businesses to reduce UFP emissions and strategies for individuals to avoid high UFP concentrations.

BACKGROUND

Denmark has taken a progressive stance with regards to environmentalism and expressed their interest with a series of long term plans that aim to reduce climate change and pollution. Recent plans include the 2050 plan, a plan to make Denmark fossil fuel free by 2050; eco-metropolis, a plan to make Copenhagen the "world's best city for cyclists" by 2015; and Cityringen, a plan to construct additional metro lines and stops by 2018 to increase public transit use and decrease vehicle use (The Danish Government, 2011; City of Copenhagen, 2008; Cityringen, 2014). The residents of Copenhagen consider air pollution to be the most important environmental issue their city faces in regards to public health.

Air pollution causes 2.4 million deaths per year, globally (Guilford, 2013). The health effects of air pollution are most common in the respiratory and cardiovascular systems especially in at risk individuals such as children and the elderly. Immediate respiratory effects from inhalation of vehicular emissions are wheezing, dizziness, and irritation of airways. More severe effects include but are not limited to oxidative stress and increased inflammatory response (Brook, 2008; Douglas, Haldane, & Haldane, 1912; Mills et al., 2008). Oxidative stress and increased inflammatory response are linked to cancer, Parkinson's disease, and Alzheimer's disease (Brook, 2008; Douglas, Haldane, & Haldane, 1912; Mills et al., 2008). Ultrafine particulates, particulates less than 0.1 μm in diameter, are the most harmful particulates in regards to human health because they are small enough to enter the blood stream, travel systemically through the body and directly damage organs and cells (Oberdorster, G., 2000; R. D. Brook et al., 2002). Children are high risk and high priority individuals concerning air pollution because they are developing, active, and breathe through the mouth as opposed to the nose (Clark, Demers, & Brauer, 2010; Burtscher, Schuepp, 2012).

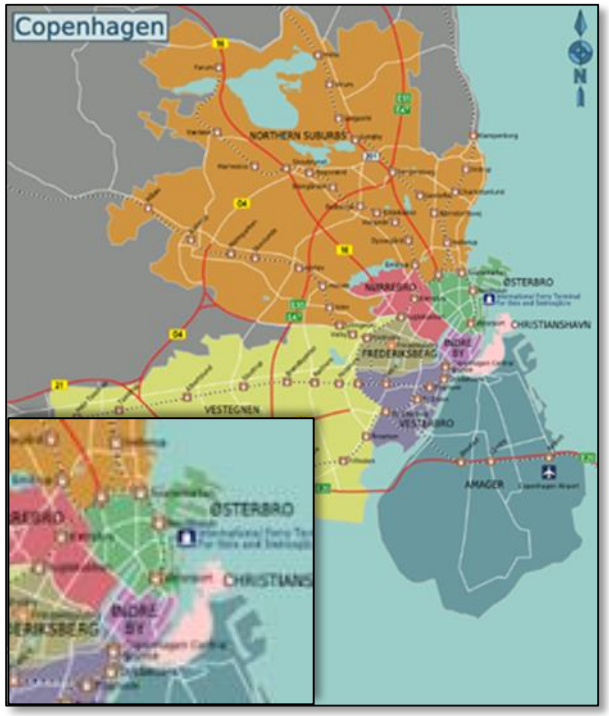

Figure 1. Map of Copenhagen with Østerbro shaded green

Østerbro, shown in Figure 1, is one of the ten districts of Copenhagen. It is a residential district with 16 grade schools. Located northeast of downtown Copenhagen, Østerbro, is surrounded by large roads, the O2 and Helsingørmotorvejen, and has four construction sites related to Cityringen. Diesel vehicles, such as those used in construction, are associated with higher concentrations of ultrafine particulates (Peya, Querola, Alastueya, Rodriguez, Van Dingenend, 2014). While the Danish government has plans that will reduce future air pollution concentration, such as expansion of mass transit, the construction required to implement these plans increases current air pollution concentrations. Currently there is no data for ultrafine particulate concentrations in the Østerbro district. Østerbro residents are concerned about air pollution concentrations in the district and the health risks posed to their children.

Miljøpunkt Østerbro, the sponsor of this project, is a non-governmental organization that focuses on sustainability in Østerbro. They are particularly concerned about air pollution and the resulting negative health effects because of the large at-risk population, composed of elderly and young children in Østerbro (Lene Midtgaard, personal communication, 2014). In previous projects, Miljøpunkt Østerbro focused on the impact of pollutants on children and provided remedies to avoid or reduce exposure to pollutants. Due to the lack of ultrafine particulate data in Østerbro, the team's sponsor wanted to assess

the risk these particulates posed to children at schools.

MISSION STATEMENT AND OBJECTIVES

The goal of this project was to help Miljøpunkt Østerbro provide information to residents in order to increase awareness of air pollution in the district, especially near schools. The team took samples from various locations at different times to determine and plot ultrafine particulate concentrations.

The objectives of this project were to:

1. Record ultrafine particle (UFP) concentrations in conjunction with observations of:
    a. Weather
    b. Traffic events
    c. Other potential data anomalies
2. Arrange the air pollution data in chart form
    a. Remove outlying data with observations 1.a-1.c
    b. Compare pollution concentrations against time and distance
3. Use analyzed data to:
    a. Support advocacy for better habits and emission regulations in Copenhagen
    b. Provide suggestions on how to avoid high concentrations of UFP
4. Display information for public view, using an article released by Miljøpunkt Østerbro

METHODOLOGY I

The team measured ultrafine particulates in the Østerbro district near schools and high congestion areas during rush hour and non-rush hour times. Miljøpunkt Østerbro used the measurements, analysis, and suggestions to provide information to residents about ultrafine particulate concentrations and solutions to better protect the health of at-risk individuals.

Miljøpunkt Østerbro provided a map of Østerbro indicating the specific focus locations, including schools and high congestion areas. The team took measurements using the P-Trak Ultrafine Particle Counter and determined taking multiple 20-minute measurements instead of fewer longer measurements limited variables, such as weather from skewing the data. The team recorded all necessary observational data in a notebook along with the date, location, and time. These observations were key in the analysis phase when the team determined if there was a correlation between particulate concentrations and the presence of traffic.

ANALYSIS I

After the team measured and analyzed the first set of locations, the data showed minimal correlation between high traffic and high concentrations of ultrafine particulates. The team expected the Trianglen, an area congested with traffic, to show the greatest correlation between increased concentration and increased traffic. Figure 2 compares the differences in ultrafine particulate concentrations caused by traffic and construction. From this graph as well as those for a few schools, the team found a minimal correlation between increased traffic and increased ultrafine particulate concentrations. During further analysis of the data, the team reviewed the observational data collected at the time of measurement. The team noticed that areas near construction had higher averages and larger spikes.

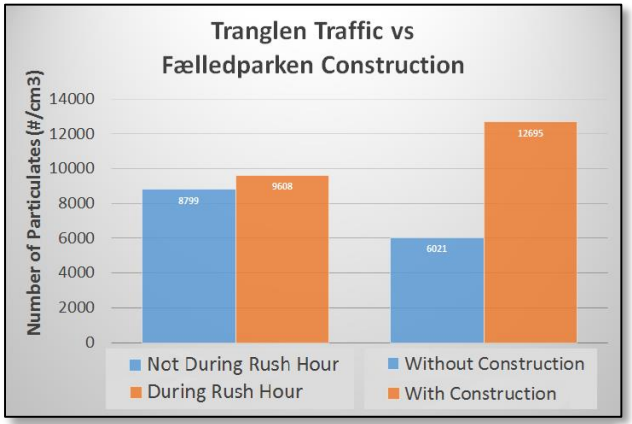

Figure 2. Comparison graph of traffic versus construction

METHODOLOGY II

The team selected a new set of locations, with and without construction, from the original list of schools and locations. The primary criteria for selecting locations were the site's proximity to schools; size of the construction site; whether barriers surrounded a site; and a lack of potential interference, such as diesel vehicles. Using these criteria, the team reduced the number of locations from the 24 schools and high congestion areas selected during preliminary measurements to five. The five locations included two schools in close proximity to construction, two schools with no nearby construction, and Fælledparken, because the site had barriers. The team took measurements at construction locations similar to those described in Methodology I.

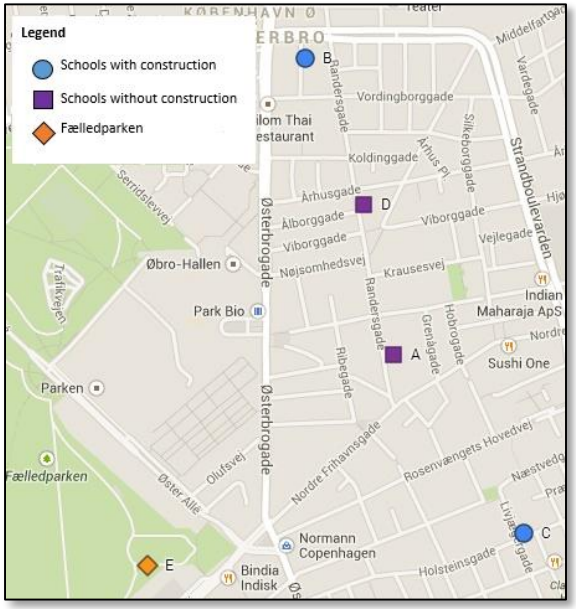

Figure 3. Map of New Measurement Locations

ANALYSIS II

The team used several graphs for each construction site to display data including: the average number of particulates over a 20-minute period versus distance from the construction site; the average number of particulates each minute for 20 minutes at each distance versus time; and the number of pollution spikes at each distance. A spike is any second spent above the acceptable baseline of 10,000 particulates per cubic centimeter presented to the team by the Danish ECO Council representative, Kåre Press-Kristensen.

The graphs in combination with observational data showed that ultrafine particulate concentrations near construction sites dissipate over distance and noise barriers decrease concentrations in the immediate area. Both Vibenhus Skole and Langelinieskolen, the schools with construction, showed a negative correlation as distance increases from the construction site, see Figure 4 for Vibenhus Skole. There is a safe distance from a construction site but it will vary due to weather and site size. A distance of 50 meters is safe for construction sites of similar size to the ones near Vibenhus Skole and Langelinieskolen. The average value at 50 meters was below the baseline, and the number of spikes at each site, seen in Figure 5, were insignificant when at or beyond 50 meters. The team used the schools without construction for comparison to see if construction adds a significant amount of pollution and to determine if schools fall below the baseline provided by Kåre Press-

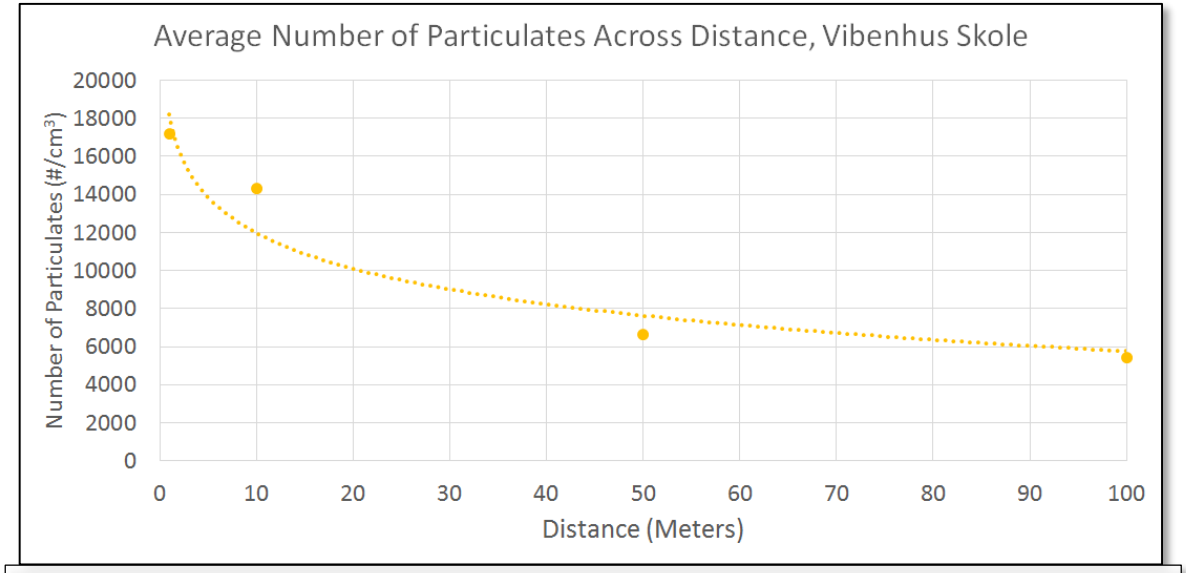

Figure 4. Graph displaying the average number of particles for each distance, as well as a trend line to anticipate where unmeasured distances would fall.

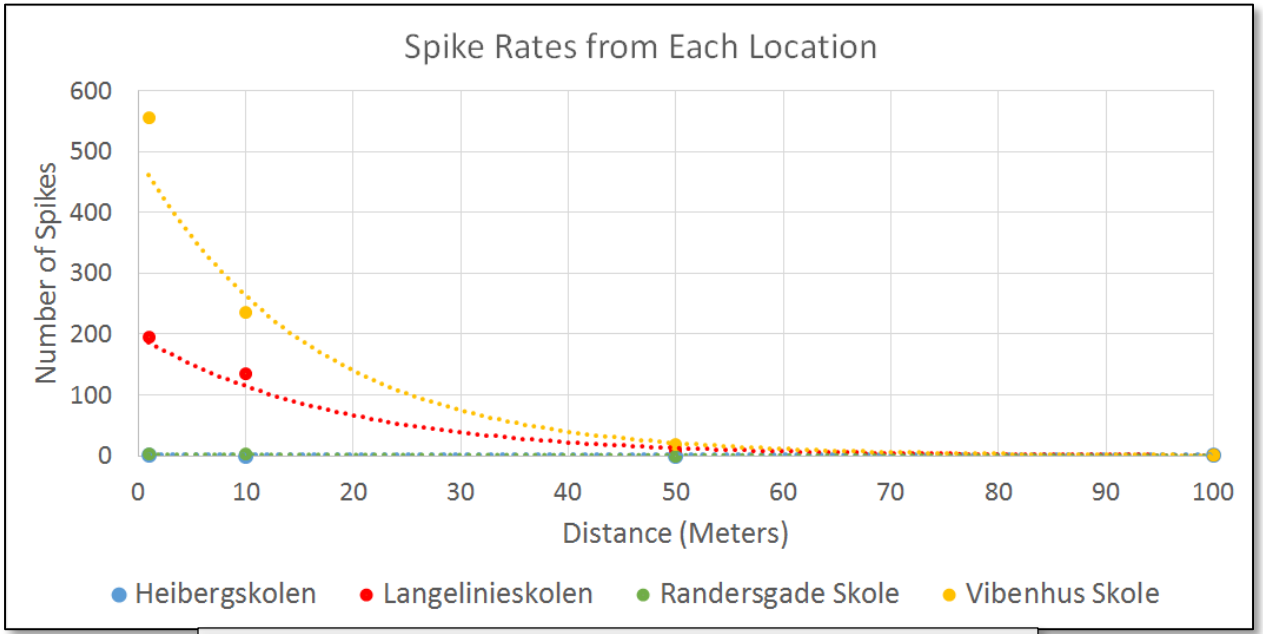

Figure 5. Graph displaying the spike rate of all schools.

Construction Companies	General Public
•Barriers at all sites •Reduce idling time •Install diesel particulate filters (DPFs) •If near a school •Turn off engines ½ hour before and after school hours	• Keep distance of 50 meters from construction • If solid barrier present and 50 meter distance is not possible, keep distance of 1 meter or less

Figure 6. Suggestions for construction companies and the general public.

Kristensen. The averages the team measured at the schools without construction were below the baseline value.

SUGGESTIONS

Using the results from the data and analysis, the team created a list of suggestions for construction companies and the general public, as outlined in Figure 6. Miljøpunkt Østerbro used the data and suggestions to propose habit changes to construction companies to decrease the amount of and exposure to ultrafine particulates.

The team determined that at a distance of approximately 50 meters from a construction site, ultrafine particulate concentrations are close to normal background values and are considered safe. If it is not possible to be 50 meters away from a site, it is best to stay as far away as possible because the concentration of particulates decreases exponentially except in one important case: the presence of solid noise barriers. If barriers are present, and it is not possible to be 50 meters away, then it is best to maintain a distance of 1 meter from the barrier. The area one meter or less from the barrier had a much lower concentration of ultrafine particulates compared to a distance of 10 meters. These suggestions of distance to construction site apply to the sites of similar size in the Østerbro district, as well as the city of Copenhagen.

In addition to avoidance of high concentrations of ultrafine particulates, it is possible to reduce the output of these particulates. Suggestions are installing solid barriers around all construction sites; reducing idling time; installing diesel particulate filters; and, when near schools, turning off diesel engines half an hour before and after school hours. The team makes these suggestions aiming to reduce exposure to high ultrafine particulate concentrations from construction sites. The team believes that further research into the health effects and the implications of construction is necessary to protect the health of children and city residents.

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