Building Bridges: Connecting Air Pollution Awareness to Inner City Copenhagen

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Abstract

Particulate pollution levels in the heavily trafficked neighborhood of Indre By in Copenhagen, Denmark exceed the World Health Organization's standards and are linked to negative health effects. While air quality information is available, individuals lack the understanding of its direct effects and information about how to take personal action to reduce exposure. Our team designed a media campaign and tested strategies to disseminate air pollution information to different audiences through the use of social media, digital content, and physical posters. Through research, expert advice, and analysis of engagement, final recommendations were made to Miljøpunkt Indre By & Christianshavn for future multi-media campaigns.

Executive Summary

This project aimed to reduce the information gap surrounding particulate pollution in The Lakes region within the neighborhood of Indre By through the dissemination of a multimedia awareness campaign and to develop suggestions for future dissemination efforts by Miljøpunkt Indre By & Christianshavn.

Air pollution at the street level can be broken down into different categories based on particle size, and this project focused on the presence of **fine and ultrafine particulate matter. Ingestion of these forms of particulate matters can lead to adverse health effects** such as asthma, cardiovascular and heart disease, COPD, and in extreme cases premature death. Miljøpunkt Indre By & Christianshavn, an environmental organization in Copenhagen, Denmark, focused on local environmental health and reducing the negative impacts of pollution, sponsored this project to **produce and disseminate a media campaign to increase awareness of particulate air pollution as well as to assess strategies that could increase engagement in future media campaigns**.

The goal of this project was to reduce the information gap regarding particulate pollution in the Indre By neighborhood near Dronning Louises Bro, an important bridge crossing the Lakes area of Copenhagen. This bridge is near several schools, a residential area, and commuter hub, and is reportedly crossed more bicycles each day than any other bridge in the world. **To achieve the goal of our environmental campaign, our team completed four main objectives**:

- Identify target audiences for dissemination of environmental information
- Create a variety of messages in multiple media for different audiences within the target neighborhoods of Indre By effectively
- Test media campaigns on the local population
- Assess the effectiveness of the media campaign by tracking the interaction of various platforms

The **first objective identified the audience of the campaign as the residents and commuters of Indre By**, specific to the area around The Lakes and the Dronning Louises Bro. Furthermore, on digital platforms, the intended audience also includes followers and viewers of the Miljøpunkt Instagram, Facebook, and website pages. To complete our **second objective, our team created four posters and two digital infographics as content for the campaign**. The messages engaged different audiences based on the information and platform presented. Third, **to test this messaging, we posted physical and digital content and tracked engagement and interactions** via social media and QR scan analytics. Fourth, to assess the effectiveness of the campaign, we compared the interaction data and overall engagement with the material.

Figure 1: Arial view of Indre By (looking south) with Relevant Project Locations

(Google Earth, 2021)

The scope of our project was spatially limited to the Indre By side of the Dronning Louises Bro and The Lakes which separate the administrative areas of Indre By and Norrebro. **Our team collected ultrafine particulate measurements at the four-way intersection in front of the bridge and displayed physical posters on the air quality monitor and at Niels Brock International School**.

In order to disseminate information regarding particulate pollution to the public, **we developed a series of messages that could be displayed both physically and digitally, shown in figure 2**. Each message contained a concise statement about driver, child, cyclist, and pedestrian exposure to car-related air pollution. A Quick Response (QR) Code was also included as a means for viewers to learn more about their contribution and exposure to particulate pollution. After scanning, individuals would be directed to the *Clean Air* page on the Miljøpunkt website, where information about exposure levels and personal action steps to reduce emissions and exposure were readily available.
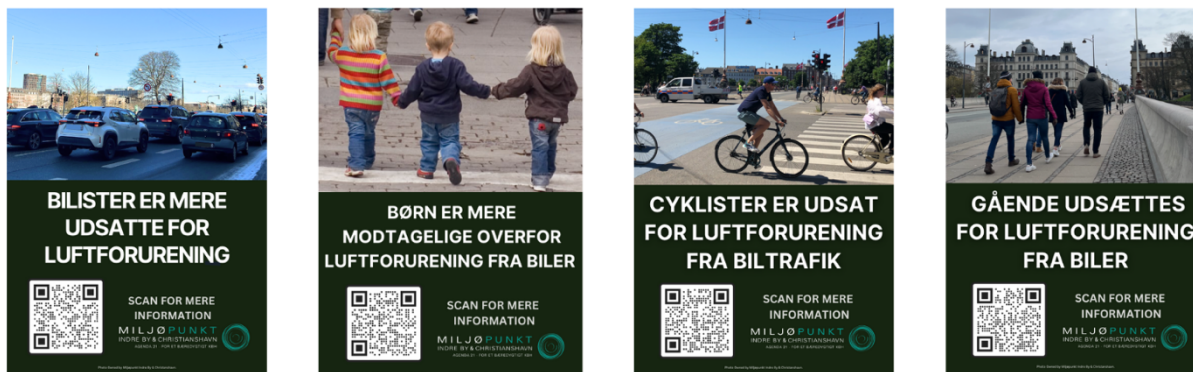
Figure 2: Overview of Final Poster Iteration

Throughout the duration of the project, **multiple iterations of the messages underwent development based on recommendations from experts on similar environmental awareness campaigns**. Specifically, we received feedback from employees at Miljøpunkt, Christian Gaarde Nielsen at Copenhagen Solutions Lab, and a local environmental committee with representatives from seven different regions around Copenhagen. Consistent points of **feedback related to standardizing the messages, using simple statements, and including local pictures**. In terms of standardization, we created the **final iteration of the posters using a consistent layout**, with a dark green bottom half, the QR Code in the bottom left, and the statement to be directly below the picture. **Each poster refrained from using overcomplicated statements** with extensive statistics in order to engage the widest audience possible. Lastly, **we included local pictures that we took of residents** around The Lakes in order to emphasize a feeling of closeness to the issue.

Following the development of the media, the **three dissemination strategies** that we chose to use to disseminate our created messages were **social media, digital posters, and physical posters**. These strategies were determined based on platforms that the team thought would guarantee interaction, and also based on general resources to which we had access via Miljøpunkt.

Reviewing the results of the social media campaign, the data showed that engagement increased on all platforms--Instagram, Facebook, and Miljøpunkt's website--doubling on Instagram and the website. This widespread increase was an indicator that these strategies were effective. We attributed much of the **increase in viewership on social media to a variety of factors including engagement boosting strategies**: hash-tagging, location tagging, posting consistently and interacting with followers, as well as the adjustments made to content through feedback.

Throughout the multi-media campaign, we were able to **quantify increased awareness by observing interaction with the physical posters through QR Code scans, as well as an overall increase in engagement on Miljøpunkt social media**, specifically on Instagram and Facebook. The increase in social media activity led to heightened traffic on the website, as the pages were linked to posts. The increase in website traffic was more indicative of individuals'

continued interest in the topic and that the information provided in the posts was engaging enough to elicit ongoing interest.
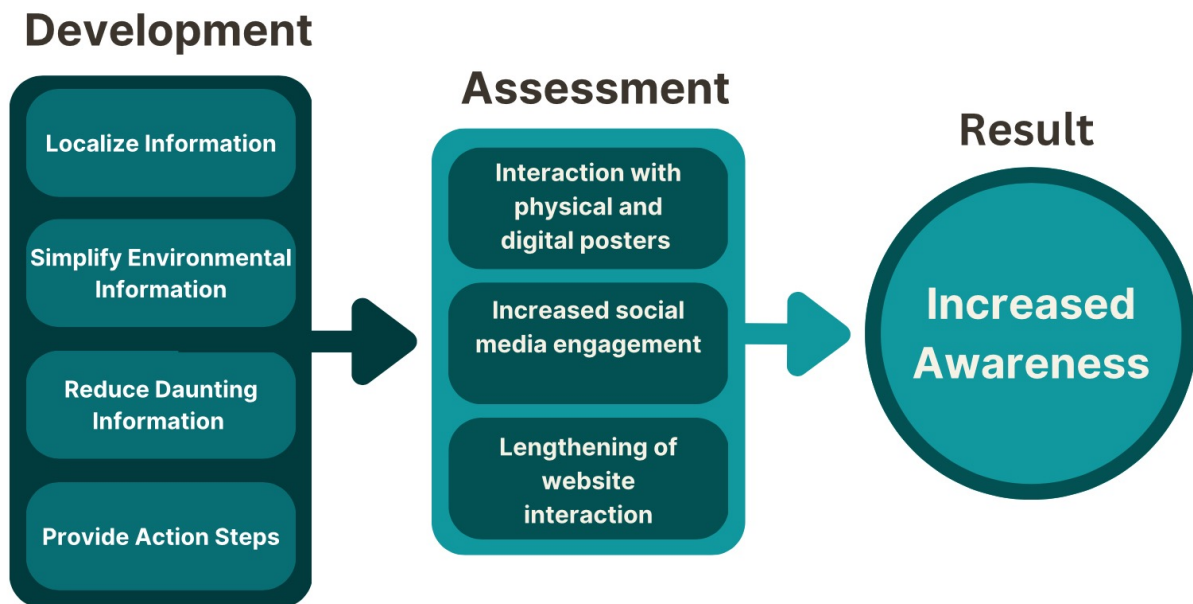
Development

Localize Information

Simplify Environmental Information

Reduce Daunting Information

Provide Action Steps

Assessment

Interaction with physical and digital posters

Increased social media engagement

Lengthening of website interaction

Result

Increased Awareness

Figure 3: Graphical Representation of Achieving Awareness

After analyzing the successes and failures of our media campaign, and after gaining insights from professionals who have worked on similar projects, **we developed four recommendations for future Miljøpunkt environmental campaigns**.

- Localize the information
- Simplify complex environmental concepts
- Reduce overly daunting information
- Provide solutions for citizens to take action

Our group found there was more engagement and impressions on posts that used local information about air pollution and pictures of the area. We posted infographics that used cartoon art to tailor toward a wider audience. These posts did not perform as well compared to the posters developed using localized information on social media. The number of impressions, likes, and accounts reached by localized information were much greater than that of an infographic.

To engage the audience effectively, **use simple statements about environmental and technical information**. The posters we developed consisted of clear and concise statements that attracted the attention of the viewer. When the information is digestible and easily understood, the viewer has a greater interest in learning more and proceeding further into additional content.

Reducing the usage of daunting information to retain the attention of the audience for initial posts helps draw them in further and remain open to additional information. **By creating messaging that references air pollution and its effects without conveying overly technical and potentially fear inducing information initially, viewers engage more intensely with the media and seek out further knowledge** rather than creating fear and disengaging them. We chose to exclude statistics regarding consumption of air pollution as they may create a sense of panic, dissuading the reader from pursuing additional information.

In order to further the success of future air pollution media campaigns, it is important to **include action steps** that an individual can take to promote greener initiatives themselves. Providing solutions ensures citizens that they can partake in clean practices to lower emissions and exposure to particulate pollution, and therefore reduces any feelings of hopelessness or apprehension around the topic. **In our media campaign, we included a QR Code that linked to the Miljøpunkt website, where recommendations** for pedestrians, cyclists, drivers, and the general resident could view strategies to lower their exposure or emissions.

Although the Copenhagen municipality supports extensive sustainability efforts to promote a "greener" city, in the neighborhood of Indre By, particulate pollution at the ultrafine level is a threat to human health. It is crucial that the residents and commuters of Indre By, specifically around the Dronning Louises Bro and The Lakes, have proper awareness of the pervasiveness of air pollution. **To increase the understanding and general awareness of the effects of particulate pollution, our team conducted a multi-media campaign and found strategies that are effective for spreading information to the broader public**. To minimize the gap in knowledge surrounding the issue, our team aimed to create and disseminate clear messaging and content that engaged the viewer.

After analyzing the results and interactions of our campaign, and speaking with environmental professionals in the municipality, **our team provided Miljøpunkt with four recommendations for success in future media campaigns**. We found that the integration of these strategies improved awareness around particulate air pollution as interaction across all utilized platform increased significantly.

Table of Contents

List of Figures

List of Tables

Contributions

Ella Bauerle

Ella was one of the primary authors of the report, specifically contributing to the portions regarding the assessment of the media campaign, the dissemination of the campaign, reducing overly daunting information and the executive summary. Within other sections of the paper Ella was a primary editor, ensuring writing was concise and well connected to the central themes of the project. Ella was the primary contributor to the website design, utilizing WordPress to create the new pages. Ella tracked the interactions on various platforms, including WordPress, Instagram and Facebook in addition to designing graphs representing the data. Ella served as the primary liaison to external resources, connecting via email and setting up meeting times as well as leading discussion during the subsequent meetings.

Samantha Calamari

Samantha was one of the primary authors of the report, specifically contributing to the portions regarding the identification of target audiences, creation of messages, planning the media campaign, providing solutions for citizens, conclusion, and the executive summary. Within other sections of the paper, Samantha was a primary editor, ensuring the quality of the overall work. Samantha was responsible for guiding the direction of the project through delegating tasks, organizing project content, and taking notes throughout the process.

Tyler Jordan

Tyler was a secondary author and supplementary editor of the report. He was responsible for writing first drafts of sections of background, recommendations, and methods of dissemination that was edited and finalized by Samantha, Abigail, and Ella. Tyler assisted in data collection with the creation of QR codes on the finalized versions of the posters, linking them to the website. Tyler was a secondary contributor to the posters, taking pictures of the local area and ensuring they were usable in poster designs. He was also a secondary contributor in data analysis and designing graphs, putting together air quality data collected.

Abigail Pulling

Abigail was one of the primary authors of the report, specifically contributing to the sections on testing methods of dissemination, recommendations, types of media, abstract, and analysis. In various sections of the paper, Abigail was a secondary editor, assisting the primary editors in ensuring the quality of the overall work. Abigail was the primary contributor to the final poster designs, ensuring that the content was standardized and accurate. Abigail also created the Qualtrics survey and monitored the activity and responses.

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1. Introduction

In Denmark, air pollution emissions have been decreasing over the last 20 years, though effects are still felt by the everyday citizen. Particulate matter, nitrous oxides, and ozone are some of the most significant contributors to respiratory issues caused by pollution. Due to its pervasiveness, air pollution is considered one of the leading risk factors of sickness and morbidity worldwide (Lim et al., 2012). For citizens of Denmark who are already at higher risk of sickness and disease, particulate pollution has led to an increase in cases of asthma and bronchitis. Additionally, it is estimated that approximately 1,200 premature deaths in Denmark are caused annually by the presence of particulate matter (PM$_{2.5}$, inhalable particles 2.5 micrometers or smaller), ozone, O$_3$, and nitrous oxide, NO$_2$ (*European Environment Agency*, 2022).

Denmark regularly meets the World Health Organization's (WHO) standard in the average quantity of particulate pollution**. For some parts of the day such as rush hour, though, Denmark does not meet these standards**. In order to combat this, the country has placed an emphasis on the development of green initiatives. These include car-free days, less available parking, and the development of city green spaces, which has led to a decrease in driving, and therefore a decrease in air pollution. In cities across Denmark, initiatives to make the streets less vehicle-heavy and more pedestrian-friendly have been introduced to reduce ambient air pollution.

 Copenhagen has a reputation as the "World's Best City for Cyclists," but car usage has been rebounding, making up 40% of all trips that start and end in Copenhagen. This increase is cause for concern, as it results in heightened levels of traffic-related pollution (Gössling, 2013). Approximately 80 citizens die prematurely due to overexposure to air pollution within the city center, the communities of Indre By and Christianshavn, while 560 people die annually in Copenhagen due to poor air quality. In comparison, 15 people die yearly from traffic accidents which is 36 times less than those of air pollution deaths (Miljøpunkt, 2016).

Environmental organizations in Copenhagen have made strides in providing information about air pollution to the public, especially Miljøpunkt Indre By & Christianshavn, one of a network of environmental groups devoted to different regions of the city. Over several years, Miljøpunkt Indre By & Christianshavn has measured particulate matter in the air, with a focus on transit-related polluters, such as taxis, diesel buses, individual cars, etc. (Miljøpunkt Indre By & Christianshavn, 2022). While waiting for stronger legislative action or environmental regulations, Miljøpunkt aims to improve public involvement in preventative measures for air pollution. Although information about air pollution is readily available to the public in forms like the Air Quality Index (AQI) for Copenhagen and the Denmark Air Pollution Fact Sheet, it currently is not presented in a manner that engages many citizens (Oltra & Sala, 2015). **The goal of this project is to reduce the information gap** between the information about particulate air pollution and the target audiences in the neighborhood of Indre By near

Dronning Louises Bro, a bridge that crosses the Lakes of Copenhagen. **Our project aims to discover, utilize and test strategies for a social media campaign** about current particulate pollution levels to empower individuals to take action and change personal behaviors and to offer suggestions to Miljøpunkt Indre By & Chr. for methods of future media campaigns.

To achieve this mission, our team pursued four objectives:
1. Identify target audiences for dissemination of environmental information
2. Create messages for a variety of media for different audiences within the target neighborhood
3. Test media campaigns on the local population
4. Assess the effectiveness of the media campaign by tracking the interaction on various platforms

This report provides background information, our methods, and the results and analysis from completing these objectives.

2. Background

Particulate pollution contributes to increasing economic and societal problems that lead to a decrease in life expectancy, increase in welfare costs, and low quality of life. The European Union (EU) and World Health Organization (WHO) regulations implemented policies to reduce particulate pollution emissions across the world.

Information dissemination strategies are paramount to improving public health and public opinion on the issue. Textual and visual information generates a stronger belief in the severity of air pollution and enhances public participation in mitigation strategies. Ensuring that information is digestible and relevant to public needs is vital to promote change in individual behavior (McCarron et al., 2022).

2.1 Health Effects of Air Pollution

Air pollution has been proven to be an environmental risk to human health. Hazardous chemicals in the air from either natural and anthropogenic activities can lead to acute and chronic adverse health effects. Short-term exposure to air pollution can result in minor respiratory diseases such as asthma or general respiratory irritation among other illnesses. In long-term cases, air pollution exposure can result in more extreme outcomes such as stroke, heart disease, and lung cancer (Kampa & Castanas, 2008). The effects of ambient air pollution in conjunction with indoor air pollution and other sources are responsible for nearly 6.7 million premature deaths annually, with ambient air pollution alone estimated to be responsible for 4.2 million premature deaths in 2019 (World Health Organization, n.d.).
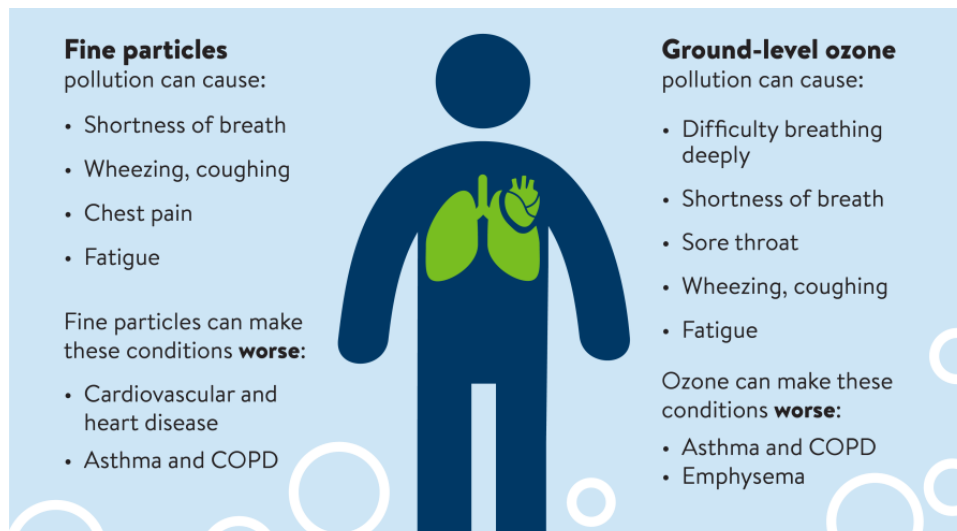

Figure 44: Effects of Air Pollution on Health

(*Air Quality and Health*, n.d.)

As detailed in Figure 4, chronic exposure to these pollutants can reduce lung function and are also responsible for susceptibility to asthma, emphysema, and lung cancer. Within the cardiovascular system, carbon monoxide, a toxic gas produced from the incomplete combustion of carbonaceous fuels, binds to hemoglobin and reduces its ability to convert oxygen. Reduced levels of oxygen can impact the functions of other organ systems throughout the body. Aside from inflammation, subjection to particulate matter can impact blood coagulation, and in turn changes in blood clotting can obstruct blood vessels leading to larger issues like myocardial infarctions (Kampa & Castanas, 2008).

2.2 What is Particulate Pollution?

Particulate air pollution is a category of air pollution that can be broken down into different subcategories based on particle size. The particles are often on the scale of 2.5 micrometers in diameter or smaller $PM_{(value)}$. Due to the small size, density, and surrounding thermal environment, the $PM_{2.5}$ particles are suspended in the air for longer periods of time than larger particulate matter or other forms of air pollution. Particulate matter of this size is primarily absorbed through the respiratory system and enters the bloodstream through the alveoli in the lungs (Thangavel et al., 2022).

A significant contributor to particulate air pollution emissions and NO2 emissions is diesel-fueled vehicles, including cars and city buses. This particulate matter is released into the environment as the fuel is consumed by the vehicle and pumped into the street through the exhaust pipes. Even though some diesel vehicles provide filtration, much of the particulate matter is fine enough to enter the surrounding atmosphere and is consumed.

2.2.1 Air Pollution in Copenhagen

Copenhagen has relatively clean air compared to other areas in the world based on air quality indexes. The city regularly meets the overarching standards for $PM_{2.5}$ concentration defined by both the European Union (EU) and World Health Organization (WHO). Air quality trends depict a decline in particulate pollution over the past 10 years, primarily due to stricter city and European directives.

While the overall emissions have declined, the general public is still at risk of experiencing the adverse health effect of the pollution (Gozzi et al., 2017). During peak commuting hours, the air pollution level exceeds the acceptable limit which directly correlates to the heightened use of diesel vehicles. In recent years, the car manufacturer Volkswagen was forced to recall vehicles that emitted more than the maximum emission standard of particulate pollution due to ineffective filters.

These problems have been noted by Miljøpunkt Indre By & Christianshavn which investigated the regulations regarding ultrafine particulate pollution and its prevalence in the city. They conducted a series of measurements on days with regular commuter traffic to compare with data collected on car-free days in the city. The study found that the most significant sources

of ultrafine particulate pollution are diesel buses, emitting up to 32 times the number of particles per centimeter cubed as natural gas-fueled buses on the same routes (Miljøpunkt, 2016).

2.2.2 Current Air Pollution Exposure

In Copenhagen, there has been an increase in the number of cars on the road, and therefore, of levels of air pollution in the inner city. When commuting by car in rush hour, it was found that the benzene concentration was three times higher in the cabin of a car compared to commuting by bicycle. The concentration of harmful chemicals such as toluene, ethylbenzene/xylenes were found to be four times higher than the benzene concentration, and three times higher on average compared to the exposure cyclists experienced (Rank et al., 2001).

Drivers experience heightened concentrations of pollution because the particles that enter the vehicle via air ventilation systems remain in the cabin for extended durations due to limited airflow. Even with filtration systems, gaseous pollutants are not prevented from entering the vehicle and continue to enter the car driving commuter's respiratory system (El-Fadel & Abi-Esber, 2009).

Copenhagen is often regarded as one of the most bike-friendly cities in the world, with extensive cycling infrastructure (European Union, 2021). Although many Danes prefer cycling for their daily commutes, it is frequently claimed that this mode of active travel is unhealthy due to exposure to transit-related pollutants (Rank et al., 2001). Despite perceived exposure, active travel is extremely beneficial to physical health. Such benefits outweigh the harm caused by air pollution except for very extreme levels of exposure (Tainio et al., 2016).

2.3 Communication of Environmental Information

Though researchers and environmentalists have demonstrated the negative effects of air pollutants on the human body and quality of life, this information has not been disseminated effectively to the population as a whole to see shifts in the societal framework for environmental awareness and action. This issue of effective communication has been identified by governmental and non-governmental organizations that would like to communicate the effects of air pollution to inspire change on individual, societal, and political levels.

2.3.1 Local Organizations and Movements

Since its founding in 2012, Miljøpunkt has collaborated with the Local Committee and The Ecological Council nearby to meet the needs and desires of the people living in Indre By and Christianshavn. In 2016, Miljøpunkt Indre By & Christianshavn completed a study regarding particulate emissions from different forms of transportation around the area, focusing on high-traffic streets. This information was released as an article on Teknologiens Mediehus, a site with news and jobs relevant to engineers in Denmark, in addition to publishing it on their own website. Miljøpunkt Amager previously collaborated with WPI to record and assess the values of particulate air pollution in Amager and its effects on school-aged children, releasing a paper with

the information. Through such studies, Miljøpunkt organizations have an impact on the general attitude surrounding climate change and air pollution, encouraging people to think more about the world around them.

2.3.2 Conveying a Message

There are a multitude of ways to capture an audience's attention, including social media, posters, metal signs, and websites. The structure of the message is extremely important to consider when deciding which method of conveyance to use (Riley, 2021). When deciding how to present the information, one "must make it clear, comprehensive, accurate, precise, understandable, and relevant to concerns at hand, with some indication of reliability or uncertainty" (Wartenburg, 2009).

The form of messaging should depend on the targeted audience. For a more scientific and data-driven audience, graphics and PowerPoint presentations are commonly used. However, for other audiences, mediums such as social media would be beneficial since this platform has been researched to be the most popular for general consumers (Saadeh, 2022).

Depending on the target audience, available resources, and time constraints, a small portfolio of dissemination strategies could be employed in our campaign. This would likely include paper posters, electronic signage, and social media, as they allow the targeting of multiple demographics.

Studies conducted with a similar range of intended audiences show it would be most effective to design separate messaging material for each target demographic (Wartenburg, 2009). Knowing this, messaging material should aim to target each audience as directly as possible while also being digestible to other populations that might view it.

Pertaining to air pollution, target audiences may include commuters, residents, vulnerable individuals, and parent populations. Where some demographics might react strongly to local-scale messaging, others may have more interest in larger-scale impacts. Understanding these trends help the creators of public communication to convey their intended message as clearly as possible (European Investment Bank, 2021).

2.3.3 Strategies to Communicate Environmental Information

Providing more accessible information to the public is crucial for the implementation of greater public awareness of environmental issues, including particulate air pollution. Environmental campaigns and initiatives depend on the empowering effect of information— the individual must feel strongly to respond strategies that are effective to share environmental information are fear-based appeals of information sharing, making the information relevant to the person, and information via posters and through social media.

Fear-Based Information

An effective persuasive use of pathos in an environmental campaign is the appeal to fear. Fear produces a strong emotional state and helps the individual recognize their responsibility to

the environment (O'Donnell & Guidry, 2022). An online study conducted by Virginia Commonwealth University highlighted how framing environmental issues in a daunting way can elicit a stronger response. Oftentimes, environmental issues are not tangible– the issue does not feel as strong of a threat if the resulting effects are not visible to the eye. Framing the issue with charged language, along with persuasive visuals can effectively communicate a threat that is seemingly invisible and therefore not pertinent to the individual.

The implementation of visuals in a fear-based campaign is extremely important, as they add to the perception of severity (Worthington, 2021). This strategy is effective in improving individual responsibility, however, a limitation of using fear as an initiative is creating a sense of shame and powerlessness, resulting in a lack of efficacy. Responsibility alone may not be enough to increase individual behavior. Attempts to mitigate this challenge would be to integrate larger stakeholders or governing bodies within the public to create a shared responsibility (O'Donnell & Guidry, 2022).

Furthermore, individuals have the tendency to care more about an issue when it directly affects themselves or their loved ones (Worthington, 2021). By utilizing this knowledge and effectively relating it to fear-based information sharing, individuals may be more open to taking action, or re-evaluating their previous beliefs if it is for their own betterment.

Inclusive Information

Citizens play a key role in implementing activities to improve air quality. Therefore, it is important to provide the individual with opportunities to modify their behavior toward their environment. Providing information that is relevant and inclusive to the specific individual can create a greater sense of collective responsibility (Abroms & Maibach, 2008).

Traditional approaches to disseminating information about air pollution can often be difficult for the public to digest. Generally, citizens are aware of the broader issue of air pollution; but facts and data can be overwhelming and lack significance if not provided in a relevant context. Social research has suggested that the public does not find the information provided by air pollution services to be helpful (Oltra & Sala, 2015).

A survey in the United Kingdom was dispersed to the public to provide a basic overview of the public's view on air quality and their view on the information provided by the municipality of London. The data suggests that there is a wish to know more about general health effects, how one can reduce exposure, and personal actions to reduce air pollution as a whole. From the survey, it is clear that there is also a strong desire to have access to information relevant and specific to the person (Beaumont et al., 1999).

In efforts to make the information more applicable to the public, air quality data and information should be tailored to the personal and/or health interests of the individual. Examples include providing information based on locations in close proximity, specific health risks, and potential diseases, crafting more emotionally charged messages, and generating information specific to the individual's needs in terms of appealing web pages or smartphone applications (Oltra & Sala, 2015).

Graphical abstract
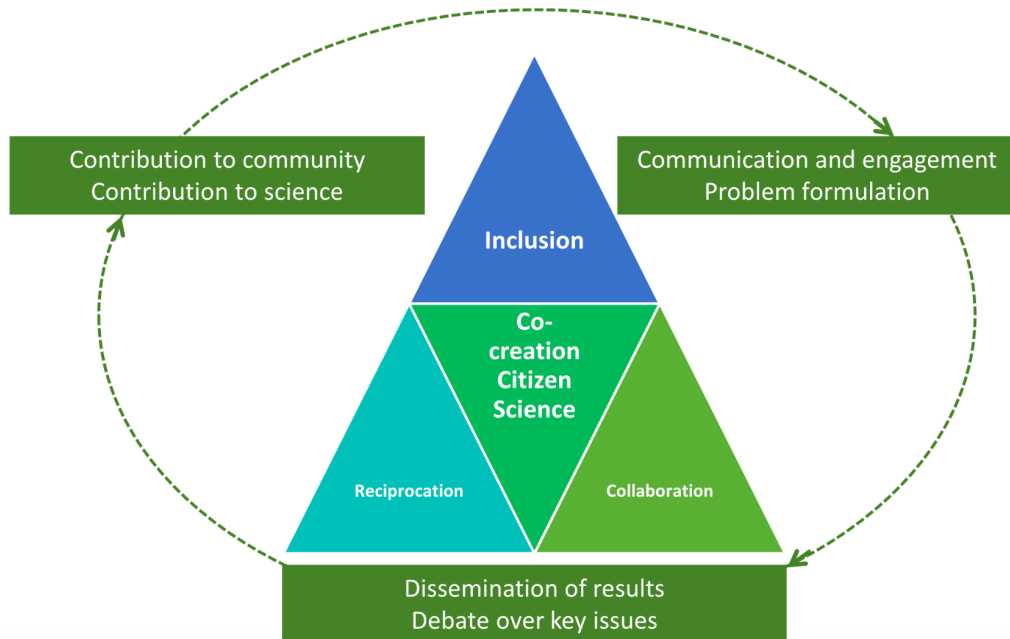
Figure 5: Graphical Approach of the Citizen Science Strategy

(Mahajan et al., 2020)

The general objectives of the *Citizen Science Approach* include the public in the process of promoting green initiatives and is shown graphically in Figure 5. Within the context of air pollution, creating the 'bridge' of knowledge is extremely important as the subject matter can be daunting and at times difficult to understand. By developing messages applicable to the community and other subsequent audiences within it, our project can have much success not only in the short term, but in the long term as well.

Print Media

Print advertisements are another way of displaying messaging. Similar to digital displays, print media can target specific demographics in a visual way. Print media is the most successful when used in collaboration with other technological messaging or media. Multimedia campaigns have the ability to "expose high proportions of large populations to messages" and are successful when sharing information, especially related to public health (Wakefield et al., 2010). Print media can range from flyers to posters and billboards and have recently been used to direct the reader to a website or location to learn more. While proven to be beneficial when tracking engagement, print media can be expensive as updated copies or iterations need to be printed repeatedly.

Quick-Response (QR) Codes

Another digital technology strategy used for information sharing is the creation of Quick-Response (QR) codes. QR codes are scannable images that can be accessed instantly using the camera on a smart device or phone. These codes can vary in size and be displayed on a variety of different media or print platforms including but not limited to electronic signs, print signs or posters, stickers, and social media posts. Every QR code is unique which will allow different QR codes to direct the individual to different information, websites, or databases. In recent years, QR codes have been used to make public health-related information easily accessible and digestible to the average citizen (Gummesson, 2016). This method of information dissemination will be utilized in our project as the QR code will direct the individual to live air pollution data specific to the location and time.

Social Media

In the past decade alone, social media has changed the way humans interact on a global scale. Social media has the ability to influence behaviors and opinions and is a massive source of information sharing. It is a great tool to share news within seconds and allows for open discussion with people in locations throughout the world. Specifically, Instagram has been used to post live streams relating to world news and with the comment feature, individuals are able to ask questions and post opinions relating to the subject (Fernandez et al., 2017). Generally speaking, social media messaging will primarily reach younger generations and will only be accessible to people with updated technology such as smartphones or tablets. However, Facebook has a slightly older audience and a design interface that is well-equipped for desktop computer access. Facebook is also the most used platform of social media worldwide with 2.9 billion active users and is also the most popular platform in Denmark (Temmesen et al., 2021). When posts are created on various platforms to target specific demographics, it will further help with the dissemination of information.

3. Overview of Methodology

The goal of our project is to disseminate environmental information about air pollution to the public of Indre By and Christianshavn. In order to achieve this goal, these objectives were completed:

1. Identify target audiences for dissemination of environmental information
2. Create a variety of messages in multiple media for different audiences within the target neighborhoods of Indre By & Christianshavn effectively
3. Test media campaigns on the local population
4. Assess the effectiveness of the media campaign by tracking the interaction of various platforms.

Spatially, this project was confined to the communities of Indre By and Christianshavn outlined in Figure 6. These neighborhoods are directly next to each other and consist of many small islands close to the inner city. The project took place during March-May 2023 (March 13th - May 2nd).

Figure 6: Map of Indre By and Christianshavn

(Google Maps, 2023)

3.1 Identifying Target Audiences

The general intended audience of the media campaign was identified as the citizens of the neighborhoods next to The Lakes and the Dronning Louises Bro (a highly trafficked bridge in Indre By). More specific audiences were identified as those who followed Miljøpunkt Indre By

and Christianshavn on Instagram and Facebook, residents interested in environmental conservation, and those who travel on the Dronning Louises Bro.

To gain understanding of the ultrafine particle presence and provide localized information to the audience we conducted a measurement at the intersection of Fredriksbrogade and Søtorvet on April 18th, 2023 from 7:41 to 8:40 am. We used a device (P-Trak) provided by Miljøpunkt Indre By and Christianshavn to record the quantity of ultrafine particles in micrograms per centimeter cubed in the air, while standing in the median of the road. We used a device provided by Miljøpunkt Indre By and Christianshavn to record the quantity of ultrafine particles in micrograms per centimeter cubed of air, while standing in the median of the road. The data from the device showed us that ultrafine particles are present in high concentrations near the Dronning Louise Bro, reinforcing our identification of the target audience. A table of the collected values are shown in Appendix G.
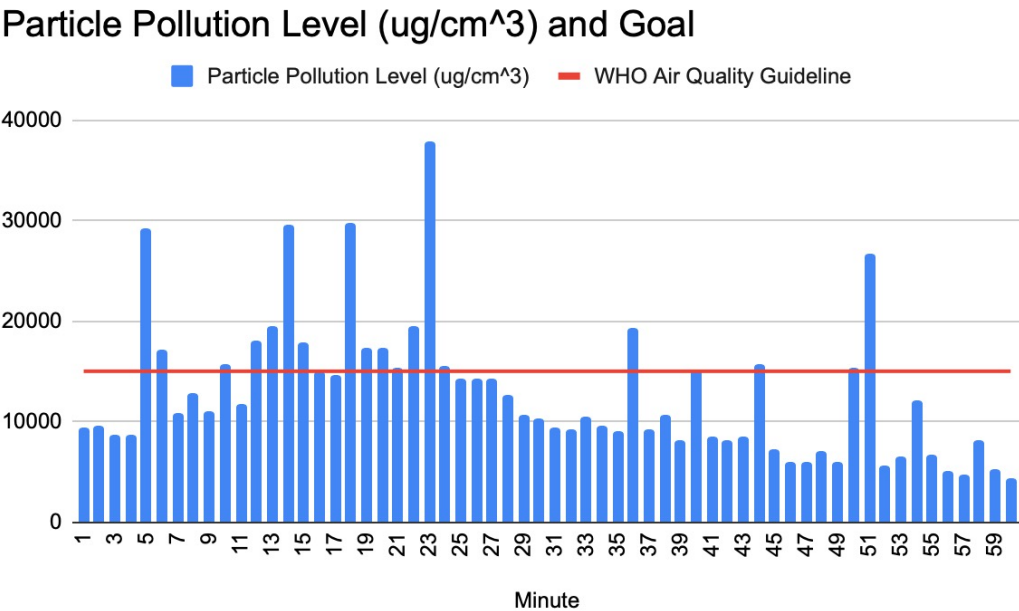
Figure 7: Ultrafine Particle Concentration Graph Over One Hour Taken April 18, 2023

Figure 7 is a graphical representation of the levels of pollution we recorded. Each bar represents an average for the minute throughout the hour. The figure shows that at multiple points throughout the hour, the level of ultrafine particle exceeds WHO Air Quality Guidelines. This data ensured that the selected audience of residents around The Lakes are exposed to heightened levels of ultrafine particles, and therefore concluded that this campaign was relevant to their health.

3.2 Creating a Variety of Messages

We drew from methods and strategies defined in the background section to devise statements that were specific and applicable to each audience. Information that is relatable, understandable, and local is more engaging than general data about air pollution. Communication that corresponds to local places emphasizes a feeling of closeness and immediacy to the issue (Riley et al., 2021). Despite the scientific nature of the information, we refrained from using overly technical language. We simplified our message to ensure public understanding (Beaumont et al., 1999).

Raising concern and anxiety about air pollution without solutions can create a feeling of apprehension and hopelessness. In order to avoid this, we employed the inclusion method from the *Citizen Science Approach*, to implement a connection between the person and their individual action (Mahajan et al., 2020). In addition to media regarding health effects, we provided reasonably actionable information that pertains to both exposure reduction and reducing one's emissions. The signage included a Quick Response code (QR code) that acts as a direct link the Miljøpunkt website. Each message would link to one of three pages within the *Clean Air* tab on the website. For messages specific to driving, the QR code would link to a page titled *Commuting By Driving*, for messages specific to active transport, the QR code would link to a page titled *Commuting on Foot or by Bicycle*, and messages about general citizens would link to *Air Pollution in the City*. Each page included information regarding the effects of air pollution, and also personal action steps individuals could take to either reduce their emissions or exposure. The webpages included links to the Air Quality Index in Copenhagen for citizens to plan cleaner routes and reduce exposure, as well as a document provided by the municipality about Copenhagen's efforts to make cycling easier in the city. Each webpage also included a link to a survey that provided the team and Miljøpunkt with more information on traveling habits. Examples of the messages are provided in Appendix D.

3.3 Testing Methods of Information Dissemination

In order to effectively and efficiently share air pollution information with the public, we tested media efforts on highly trafficked streets, intersections, and on technological platforms. We have catered the media message, format, and location of the messaging to the audience, as we aimed to reach an increased number of individuals within the communities.

Local Schools

To reach the student and parent audiences we went to a range of schools in the neighborhood surrounding The Lakes to inquire about putting up posters and using the principal's network to disseminate digital posters to students and parents. The schools that we went to were Børnehaven Hylet, Nansensgades Børnehus, Neils Brock International School, and N. Zhales Seminarieskolen, Gymnasiet, and Grundskolen. These schools include high schools to kindergartens and after-school care. At Niels Brock, we were able to put up posters in the highly

trafficked hallways near the entrances in addition to digital dissemination of the posters to the student body via the school principal. All other schools agreed to send out the posters digitally to the relevant population. This allowed us to target the parents of the children that attend these schools as well as young adults commuting to school in the city.

The Dronning Louise's Bro

The Dronning Louise's Bro is one of the most highly trafficked streets in all of Denmark and connects a variety of commuting routes. The Indre By side of the bridge, located next to the bridge on Nørre Søgade, is the municipality's air quality monitoring machine the particulate matter. It is located next to the bridge on Nørre Søgade and is where the posters were displayed from April 12th 2023. We pasted the posters on the two most viewable sides of this air quality monitor. The sides of the monitor facing the road and busy four-way intersection had posted messaging related to drivers and car emissions. The side with foot traffic displayed pedestrian-focused messaging.

Social Media Outreach

Miljøpunkt has established an active business Instagram and Facebook accounts where information is shared regarding the work of the organization and local environmental updates. We had access to the account in which we posted the digital copies of our posters, the posters out in the community, and where they were located. We posted content 1-3 times a week. Additionally, we aimed to make the Instagram and Facebook page more active in general by posting relevant information and statistics about Miljøpunkt to increase awareness and involvement. We interacted with other Miljøpunkt branch accounts and utilized hashtags related to Copenhagen and pollution to reach a greater audience. The link to the survey is posted on the main page of the account for easy access. We also used the resident mailing lists provided to us by Miljøpunkt to spread our messaging further into the community. Within this email, we hyperlinked a survey, send an image of a poster targeting the residential community, and provided links that lead to the Miljøpunkt website to learn more about air pollution in the area.

3.4 Assessing the Effectiveness of the Media Campaign

The success of a media campaign can be determined in part by the number of individuals it reaches. To gauge the success of the different dissemination strategies, we employed techniques including surveying, social media and website interaction, and QR code tracking. We employed the use of a survey to gather information about locals commuting habits, shown in Appendix C. Utilizing Miljøpunkt's email and social media networks, we sent messages and flyers with information about the consequences of air pollution exposure along with links to the survey. We used the analytics provided to us by Instagram and Facebook for business to track changes in following and interaction. Similarly, the QR code provided access to data regarding the number of scans and time of day that interactions are increased.

The survey was created to understand what motivates people to choose different modes of transportation. After providing information regarding the effects of air pollution, the survey gave us an opportunity to gauge whether or not individuals felt open to change. In gathering data about people's willingness to make small adjustments, we were able to provide Miljøpunkt with suggestions for more effective messages.

To communicate with the local residential council and email rosters from Miljøpunkt, messaging was sent out throughout the term. We included the poster images in the emails as well the link to the survey. We created additional pages on the Miljøpunkt website, showcasing a relevant poster as well as additional statistics and resources about local air pollution to inform the public further. Instagram and Facebook were used to disseminate the posters to the accounts following the inclusion of the survey link in the biography of the page.

As we employed the use of Quick Response codes, linked to the updated Miljøpunkt website, we were able to record the number of interactions with the QR code. This information shows us how frequently people take the time to stop and read our media fully and are interested enough to follow up. This tracking showed us what times of day individuals are actively interacting with the messaging when popular times to stop are, and where individuals stopped to look.

The dissemination of air pollution information is essential to raise awareness about the harmful effects of pollution on human health and the environment. By employing these methods, we highlighted the importance of educating the public about the sources and impacts of air pollution, as well as providing citizens with tools and resources to act and reduce their exposure.

These methods will give Miljøpunkt Indre By & Chr. the ability to spread awareness about air pollution further in the future. Miljøpunkt's organizational mission statement was reinforced in collaboration with our project goals to promote both individual behavioral change and societal change related to air pollution throughout the Municipality of Copenhagen.

4. Planning the Media Campaign

In order to effectively disseminate air pollution information to the local population in Indre By and Christianshavn, the team developed a series of media campaign strategies. Before dissemination, we created multiple messages that could be used for different platforms to reach the widest audience possible, while simultaneously targeting specifically the local population near the Indre By side of The Lakes. After multiple rounds of development, the messages were posted on social media, the Miljøpunkt Website, and physical locations around The Lakes. We were able to analyze the success of the campaign by tracking interactions on the online platforms, as well as QR scans on the physical posters.

4.1 First Version of Messages

Prior to arrival in Copenhagen, we created a set of messages to propose to Miljøpunkt Indre By & Christianshavn for the dissemination of air pollution-related information. The messages initially targeted specific populations of pedestrians, cyclists, and parents. The statements on each poster contained relevant statistics or facts pertaining to each demographic. Examples of the first poster samples are shown in Appendix D. These messages were displayed in English at first.

After arrival in Copenhagen, **Marianne Spang Bech** provided feedback on the poster images, and we underwent the first set of revisions for the messages. The main points of feedback during this meeting were larger, general points of criticism. Although the first iteration of media was specific to Indre By, Marianne reiterated the **importance of *local* information**. She felt that it would be best to tighten the scope even more and have **the media effort target the locals around the Indre By-side of The Lakes**. She also suggested that it would be useful polluters. In conjunction with messages that pertained to drivers, our overall messages shifted from the general issue of air pollution to that of car-related air pollution.

This coincided with other feedback for making our messages as targeted and local as possible. Additionally, instead of using generic photos of traffic, we took photos of car traffic by the Dronning Louises Bro and also used a photo of cyclists provided to us by Marianne. The photo used for the resident population regarding children also changed to follow suit with Copyright Laws.

Overall, from the first round of feedback from Marianne, **our messages became even more specific and targeted**, through the literal statements as well as the photos on the posters. With assistance from employees at Miljøpunkt Indre By and Christianshavn, **we translated our messages from English to Danish**, as the messages would be viewed at a higher rate if displayed in the local language. The first development of messages on-site are seen in Appendix E.

4.2 Revision of Messages

Following the first iteration of messages, we met with a former Copenhagen Solutions Lab employee, **Christian Gaarde Nielsen**, who previously worked on monitoring the air quality in Copenhagen with the Google Car Program. Marianne had informed him about the media campaign, and he expressed interest in meeting with us to hear about the project and provide feedback where it was necessary.

In the meeting with Christian Nielsen, we provided a brief overview of the project, as well as displayed our current messaging. His feedback pertained to all of the posters, not just one individually. Initially, the messages used different fonts and overall had different graphic designs. However, Christian thought that it would be best to **standardize the posters**. This entailed keeping the general design the same: using the same fonts, placement of text, QR Codes, Miljøpunkt logo, etc. Along with the general standardization of messages, Christian also noted that we should **simplify our statements** further. Initially, there were statements pertaining to the effects air pollution has on the different target audiences, and in some instances, a statistic was provided as well. He felt that this could be difficult for those passing by on a bike or car to read, and in general, could make the reader lose interest in the messages. As a result, we changed our messages to **short sentences**, including statements like "Children are exposed to car-related pollution". Another positive result that Christian believed would happen due to shortening the statements was to draw the reader in further. The goal of a single line of text was to **catch the reader's attention immediately**. Hopefully, piquing their interest enough to have them learn more by scanning the QR Code, and redirecting them to the Miljøpunkt website. There, facts about particulate matter and healthy alternative transport are readily available.

We also met with **the Local Environmental Committee** of seven different regions around Copenhagen. Their feedback was similar in that they believed the messages should be short and concise, and they also assisted in the spelling and punctuation of the statements on our media.

4.3 Final Iteration of Messages

We created our final iteration of messages after meeting with Marianne Spang Bech, Christian Gaarde Nielsen, and the Local Environmental Committee. The scope of the message remained the same, however, the statement itself broadened in order to appeal to a larger audience and potentially draw people in further. **All the poster samples followed the same format**, with a dark green bottom half, the photo on the top, the statement directly under the photo, the QR Code on the left, and the Miljøpunkt logo on the right, as shown in Figure 8.

Figure 8: Final Iteration of Poster About Cyclists

After the rounds of development, the team planned out different platforms of media that would be the most effective dissemination of the created messaging. We determined social media, in the forms of Facebook and Instagram, the use of the Miljøpunkt website and email

lists, as well as physical posters would be the most effective and efficient way to spread our media and allow time for citizens to view it.

5. Dissemination of Media Campaign

Through the use of social media, physical posters, websites, and email lists, the team was able to **publish the final iterations of posters** with the addition of supplementary information through the implementation of the website. Using **Miljøpunkt's active social media accounts**, the information was disseminated to audiences with confirmed interest. **Physical posters** were put up to reach audiences on the street that would pass by, and in Niels Brock Gymnasiet where high school students would interact with the posters during passing periods. The team developed new pages on Miljøpunkt's website to give viewers access to more information about air pollution and solutions, as well as a survey to track the commuting habits of people that were interested. Through Miljøpunkt's resources, email lists of residents were accessed and utilized to disseminate digital posters. Additionally, through Marianne, the team gained access to multiple schools in the area, some of which agreed to send digital posters onward to their students or their guardians.

5.1 Miljøpunkt Website Design

The Miljøpunkt website has previously been used to outline the group's current goals and active projects pushing them towards environmentally positive outcomes. Their mission is broken into four categories, Clean Air, Less Noise, Green City and Recycling. Due to the nature of our project, we chose to integrate new web pages within the Clean Air bracket, creating pages called "Commuting by driving", "Commuting by bike or by foot", and "Air pollution in the neighborhood". Each of these pages was linked to one or more of our posters, dependent upon its desired audience and provided information.

Keeping with the style of the website was important to Miljøpunkt, so each page is designed to provide further resources and information to the viewer rather than explicitly outlining information from other sources. Each web page was designed in the **same format**, with a header belonging to the sub section of interest followed by written information and hyperlinks on the left half of the screen and images of the corresponding digital poster on the right side. The focus on providing opportunities for individual change is also important to Miljøpunkt, so on each new web page suggestions for ways to reduce emissions or exposure were laid out.

To provide Miljøpunkt with recommendations for future adaptations and efforts towards campaign dissemination, we included **a link to a survey about commuting habits** to each of the three new webpages. To ensure the functionality of the new web pages, insights from WordPress were used to determine readability and navigability, with all pages maintaining the highest standard.

"Commuting by Driving"

On the page "Commuting by driving" the audience being targeted was people from within and outside of the city who use personal vehicles to commute to work. To encourage changes in behavior, sources on the web page were used to show the impacts of air pollution on the driver themself. Utilizing the strategy of personalizing and localizing information we aimed to create a sense of personal responsibility in the driver as they found that their exposure to ultrafine and particulate air pollution is higher than other forms of commuting. After providing relevant information about exposure levels, we outlined simple strategies to reduce emissions and exposure to air pollutants.

"Commuting by Bike or by Foot"

On the page "Commuting by bike or by foot" the target audiences were any individuals who do not emit particulate pollution on their daily travel to and from the city but are exposed to the emissions of those around them. This page used positive reinforcement to praise individuals using nonpolluting forms of transit. It then outlines the differences in particulate air pollution, which categories are more pervasive and what to look for when taking in information about local air pollution. In conformity with the other web pages, it provides a general outline of strategies to reduce an individual's consumption of particulate air pollution. Defining the streets that have the highest daily concentration of particulate pollution and are best to avoid, as well as heat maps with local data regarding levels of particulate pollution.

"People in the Neighborhood"

For the web page titled "Air pollution in the neighborhood" the target audience was broader than the previous pages. It sought to inform neighborhood residents more directly and to amplify knowledge about different types of air pollution as well as strategies to reduce consumption. Unlike other pages, this site included more sourced information, to improve readability and inform viewers of the air pollution in their surrounding area. This page also catered to parents of young children, as the safety of the area is very important to them.

5.2 Physical Posters

Physical posters in size A3 (11.7in x 16.5in) were put up at the Neils Brock International School, a high school located next to the Israeli Plaza. The posters were displayed on two glass doorways that are frequently used by students. The posters were also displayed on an air quality monitoring device that is located next to the Dronning Louises Bro. Here, the posters were exposed to heavy foot traffic and could be seen by bikers and drivers alike. The posters were put up on April 12, 2023, and taken down on April 20, 2023.

5.3 Email Dissemination

In addition to social media and physical posters, **emails were also used as a means to disseminate our messaging further to the communities around The Lakes**. The email consisted of files of the created messaging, a link to a survey about commuting habits, as well as a short introduction to our student team, and a general overview of the project.

In an effort to further our campaign, we asked local schools and organizations in Israel Plads if they would be willing to forward our messages to parents of the students or other interested citizens as they would see fit. Similarly, we asked the Cycling Embassy of Denmark to spread our campaign. We concluded that our messages contain information that coincides with an emphasis on bike use, and therefore prove to be interesting to employees and applicable to their work. We were also granted access to the email list for the Local Environmental Committee, as well as email lists for a group of residents interested in Miljøpunkt's work around The Lakes on the Indre By side.

In our limited study, we chose to disseminate our campaign via email, as this strategy would ensure that information would reach a wide range of locals. In the short time frame, distributing our media through emails was quick and efficient. Additionally, using the email lists was effective as those who were contacted through this means initially showed interest in environmental information as well as Miljøpunkt's projects.

5.4 Social Media

Social media posts were displayed on Facebook and Instagram. These posts consisted of the posters in Appendix F, as well as other supplemental material informing viewers about car-related related air pollution.

Utilizing insights from both platforms, we were able to understand the engagement of followers to the previous posts. In an effort to boost engagement, **posts were disseminated 1-2 times a week over a three-week period**. By posting consistently, with additional strategies to improve engagement like tagging related accounts, using hashtags, adding website links to the account biography and promoting the post, we aimed to increase the quantity and quality of interactions.

We chose to use not only the posters designed for the Miljøpunkt but additional informational posts, and infographics, to supplement the knowledge of the viewers. Infographics have become more popular in recent years as they allow Instagram users to repost information they believe is new or interesting to their own following, in a way that is visually appealing to others. By creating a series of infographics with information about car-related air pollution, we create an opportunity for younger viewers to share the account further.

Posting supplemental material will help the Miljøpunkt Instagram and Facebook gain more traction and popularity.

6. Analysis of Media Campaign

The overall success of the media campaign was quantified by the number of interactions and engagements with the posters, social media platforms, and the Miljøpunkt website. The data was generated from QR scans, Facebook and Instagram insights, and WordPress analytics. The media campaign was assessed as a whole, encompassing both digital and physical media efforts.

6.1 Success of Each Dissemination Strategy

Social Media

Both the Instagram and Facebook pages for Miljøpunkt Indre By & Chr. provided insight into viewership and engagement. **In general, Facebook has a greater viewership than Instagram with 1,024 accounts reached by posts between March 22nd and April 21st whereas Instagram reached 707 accounts with its posts between March 22nd and April 21st**. When narrowing the scope to posts created exclusively for the particulate pollution media campaign, 611 accounts were reached on Facebook, indicating that **Instagram connected posts with a wider audience than Facebook**. Through each platform engagement is also visible, which supports the claim that Instagram is more engaging to followers than Facebook with 195 and 66 engagements respectively between March 22nd and April 21st. **The increase in engagement across both platforms indicates a positive development in the interest of Miljøpunkt Indre By & Christianshavn's audience**.
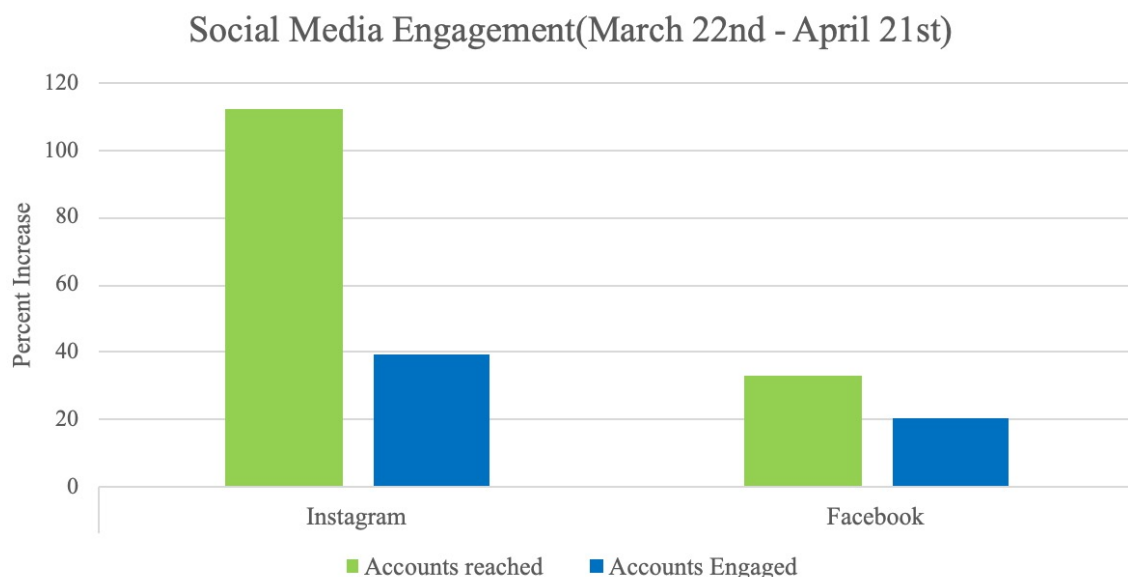
Figure 9: Social Media Engagement on Instagram and Facebook

Accounts Engaged: Instagram v. Facebook(March 22nd - April 21st)
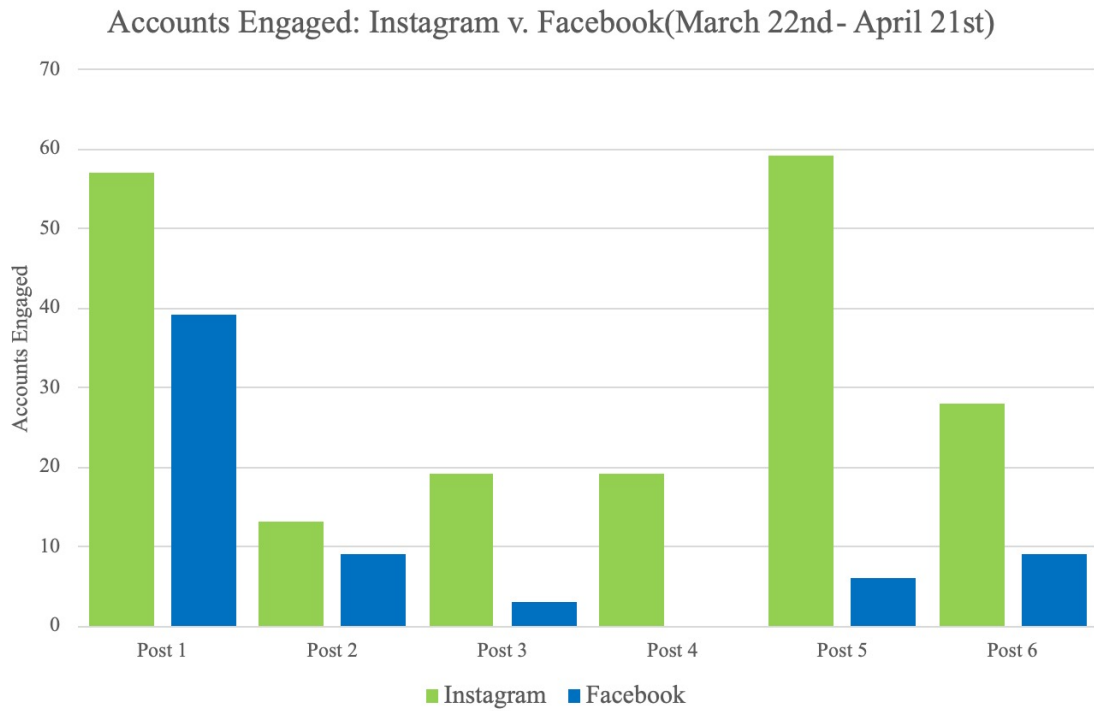
Figure 10: Account Engagement on Each Post Instagram vs. Facebook

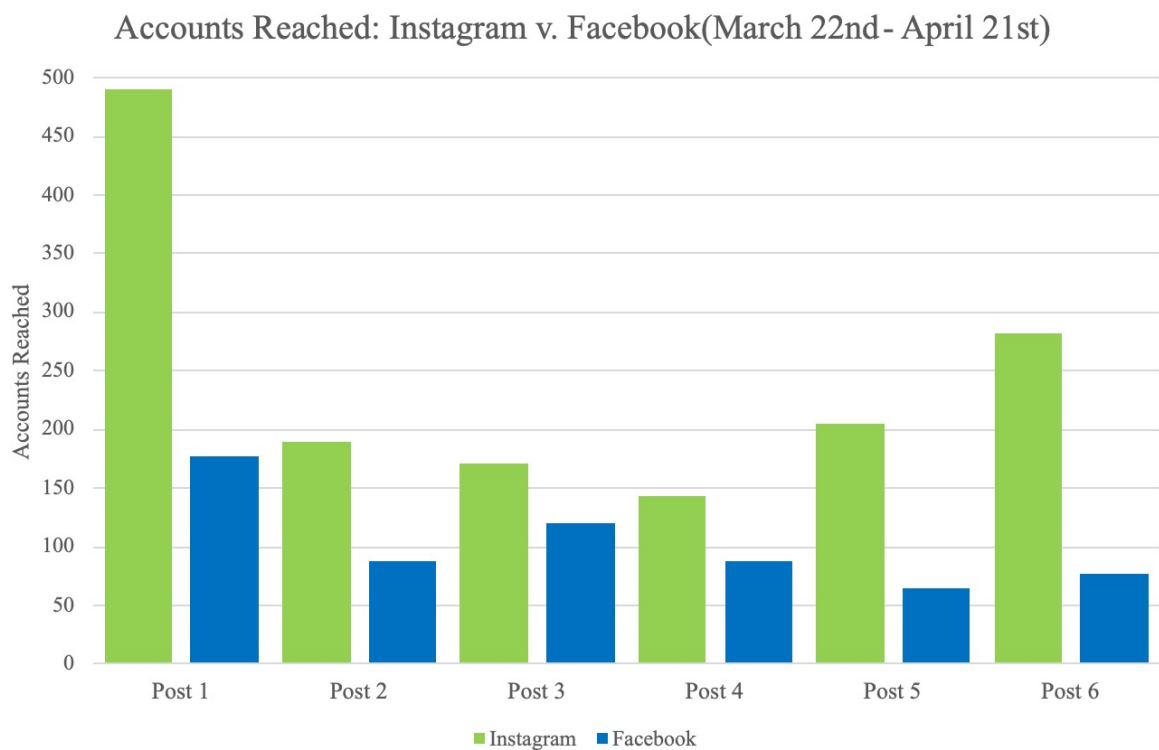Accounts Reached: Instagram v. Facebook(March 22nd - April 21st)

Figure 11: Accounts Reached Instagram v. Facebook Data gathered April 21, 2023

The figures 9, 10, and 11 show both reach and engagement of each post on the Instagram and Facebook pages. Posts 1, 2, 5, and 6 were of the posters we designed, while 3 and 4 were infographics. As seen in the data, engagement was higher on average for the posters than for the infographics. Since the infographics were designed without local information and contained more complex and technical topics and did not engage viewers as heavily as the posters did, we found that the overly complex and untargeted information was less relevant to the individual viewers.

Miljøpunkt Website

The Miljøpunkt website saw an increase in pageviews, and average length spent on the webpage. After creating the additional pages, the site saw 698 page views, a 105% increase from the previous 30-day period. Additionally, the number of sessions, defined as a browsing session of a single user, increased by 24% to 302 sessions. The number of sessions per day spiked on days that Instagram posts and emails were sent out. **The quality of sessions was also improved**, as the time spent on the page increased from 32 seconds to 1 minute 23 seconds on average. Thus, the social media posts were successful in bringing people to the website to learn more from the information on the various pages. The localized pictures and specialized information that catered to viewers from these posts correlate to this increase in traffic and visit duration. This is shown in Figure 12.
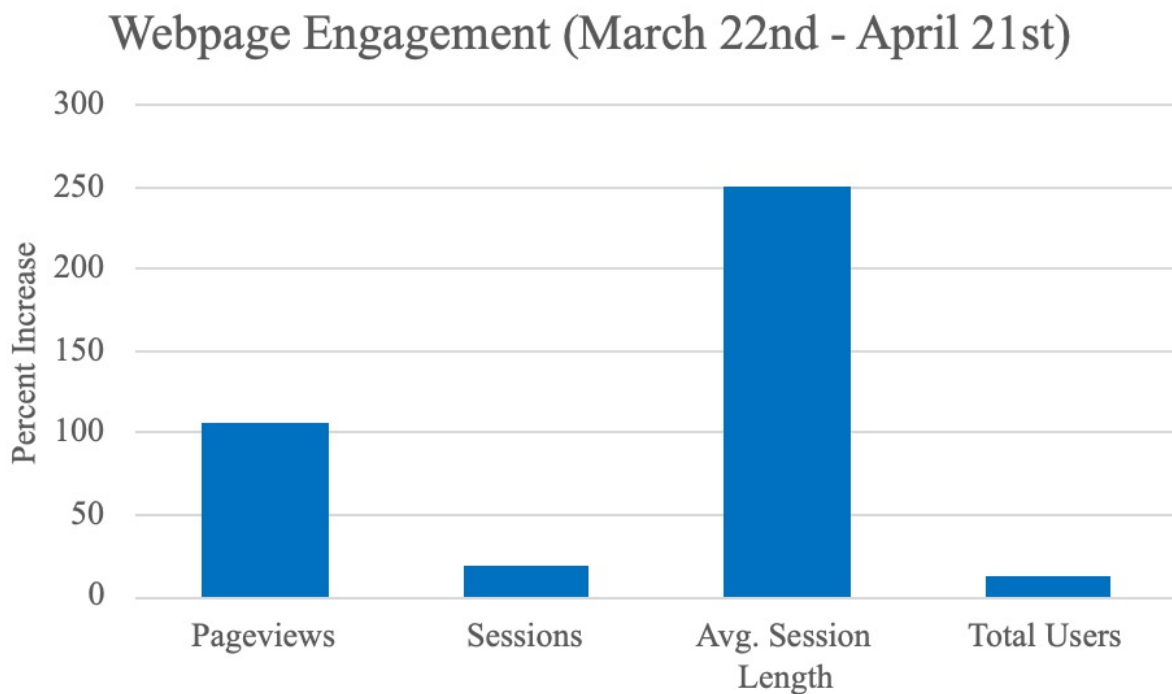

Figure 12:Webpage Engagement Statistics

Posters

  The physical posters, displayed at two different locations, were not as successful as the electronic versions when comparing the quantity of QR scans. The QR code scans that led to visits to the Miljøpunkt website were the following for these pages: the resident (17), biker (16), walker (12), and driver (31). The location of the scans could not be determined as the scanning tracker software utilized the device's sim card location and not the individual's physical location. The information on location of scans would have been helpful to understand where the posters were located that individuals scanned. By using a different QR code for the physical posters, the scanning results were separated into two categories: scans from the physical posters and scans from the electronic copies. Displayed below is the breakdown of each. These results indicate that the electronic versions were more successful than the physical posters at gaining an individual's attention and leading them to scan for more information.

  The survey on the Miljøpunkt website appeared on pages linked to the poster QR codes but did not produce significant results. There were few responses, and some individuals only partially filled out the survey, these results cannot be used to represent the intended audiences. The **limited and insufficient responses to the survey** indicate that surveys circulated in this manner may not contribute effectively to future media campaigns. Overall, the responses gained from the survey were beneficial in gaining some insights into how different people commute and why they travel the way they do. However, a larger response pool would have provided a greater understanding of transportation habits in the neighborhood.

Digital Content Versus Physical Poster

  Overall, the digital content had more user interactions and engagements as opposed to the physical posters. However, this data is difficult to accurately compare because the posters were displayed for a shorter amount of time and only at two locations. After speaking more with Mathias Vestergaard Nielsen from the Copenhagen Municipality Health Department and learning about the successes of the previous municipality campaign, it can be assumed that with more time and funding, the physical posters would have increased engagement. **Due to the lack of funding and time constraints, our displayed content was small in terms of poster size and quantity**. Furthermore, two out of the six social media posts were educational infographics that highlighted the effects of particulate pollution. These two posts received less engagement and were not interacted with as much as the digital posters were on social media. This could be due to the technical environmental language and lack of personalized messaging.

7. Recommendations

After analysis of our own media dissemination, as well as conversations with professionals who have prior experience working on similar environmental media campaigns, we propose **four recommendations to Miljøpunkt Indre By and Christianshavn for the continuation of this campaign or for new campaigns to follow**. The recommendations are: localizing the information that is being disseminated, simplifying the complex concepts that describe particulate pollution, reducing the amount of daunting information being presented, and providing solutions for citizens to take action to reduce emissions and exposure.

7.1 Localize Information

In the dissemination of environmental media campaigns, **localization of information establishes a connection between the content and the viewer on a personal level.** Specific and recognizable information allows the viewer to contextualize the content, connecting them to the displayed message. Ultimately, this narrows the scope of the campaign and increases the effectiveness of the messaging.

As a result of conversations with experts and personal research, we have found that **individuals respond better to information that they can relate to**. Specifically in the neighborhood of Indre By, residents will be more reactive to pollution information when directly connecting it to the locations and streets they frequent. **To increase this connection, our team utilized photos of the area surrounding the Dronning Louises Bro in our messaging**. We photographed bikers, walkers, and drivers on or near the bridge during highly congested times of the day to provide context to the specific areas and people affected by the particulate pollution. This strategy was beneficial as the photos tied the message to the location and personally related the content to the viewer, ultimately leading them to want to know more about the information.

To gain insights into the successes and failures of previous municipality air pollution campaigns, our team met with Christian Gaarde Nielsen from Copenhagen Solutions Lab who worked with Google Street View to measure air pollution in the city. He emphasized that the municipality's campaign displayed general messaging with electronic graphic art, consisting of simple illustrations as opposed to photographic images; it did not encourage viewer engagement. Christian encouraged us to use pictures of the area around The Lakes and air pollution information specific to the neighborhood to have a more profound effect on the viewer. To explore the connection between localized information and viewers we created additional infographics without images of the area and posted them on both the Instagram and Facebook. These posts, Post 3 and Post 4, did not engage the audience on either platform as much as the poster designs, shown in Figures 10 and 11 from the analysis. Below in Figure 13 the infographic cover slide is shown beside the localized poster image.

Figure 13: Comparison of Infographic and Local Poster

Additionally, our team stood at an intersection at peak rush-hour (07:41-08:40) and collected data to use as supporting information for our messaging. The ultrafine particle concentration data gathered was specific to the intersection on the Indre By side of the Dronning Louises Bro. Additionally, the exposure concentration was collected one meter above the ground opposed to three meters, which is the standard height for measurement. By collecting the data closer to the average human height, the data is localized to more accurately depict the exposure concentration of the commuters at that intersection. When combined with the local photos, this specific data will have the greatest impact on the viewer and will most effectively connect the individual to the message.

Ultimately, we recommend that in future Miljøpunkt campaigns, the messaging and media content should be localized to increase engagement and the connection between the viewer and the goal of the campaign.

7.2 Simplify Complex Concepts

Scientific information and data are difficult to present to a viewer in a manner that is digestible and easily understood. When spreading information to the masses, specifically related to air pollution and human health, the content must be simple enough for the average person to understand and reflect on. When the information is processed easily, the viewer will be more interested in learning more and proceeding further into additional content.

After meeting with Mathias Vestergaard Nielsen, it is evident that a successful media campaign specific to public health must have simplified messaging. Mathias previously worked on an air pollution campaign in which he explained the struggle of sharing crucial information in

a way that makes sense to viewers. He found that it is best to share a broad statistic or piece of information and link it to a more detailed explanation and higher-level content.

In our campaign, we followed a similar structure where our posters and media content contained a singular sentence of text relating to exposure levels of air pollution. Originally, our first iteration of posters displayed statistics as well as a statement about exposure levels. The statistics were not straightforward and could have been easily challenged due to the complexities of measuring air pollution. After further guidance, our team removed all nuanced information from the posters and kept the message short and simple. This simple language left little opportunity for confusion and removed barriers associated with overly technical jargon.

The simplification of complex content engages a larger audience and improves the chance that the audience processes what is being said. Oftentimes with scientific data, the average viewer gets lost or confused when attempting to contextualize and grasp the point of the message. **Getting straight to the point keeps the attention of the audience and allows the viewer to share the information more easily**. Ultimately, for the success of a future Miljøpunkt multi-media campaign, we recommend simplifying complex environmental information as the engagement relies on clear and digestible messaging.

7.3 Reduce Overly Daunting Information

To engage and to connect an audience more deeply with the information provided, the viewer must have a personal stake in the issue. This connection is most effectively developed through the integration of fear-based statements. With the use of fear comes the potential for overuse and the negative ramifications that come with it, most importantly the disengagement of the target audience due to overstimulation.

After conversing with Christian Gaarde Nielsen, the emphasis on the use of clear, concise and less specific information to draw the viewer in was expressed. To ensure that viewers are taking in content without feeling overwhelmed is critical to their continued interest. If information is too complex or inspires too much fear, viewers will move on from it quickly in an effort to get rid of the negative reaction they have. Finding the balance between using fear to retain attention versus overusing fear and losing attention completely is difficult, as different audiences tolerate differing levels of fear.

Through the posting of both the digital posters and infographics on the Instagram page a comparison between the two was possible. The infographics leaned more heavily on the use of somewhat technical verbiage, attempting to explain the nuanced nature of particulate air pollution to the viewer. The information was followed by offerings of potential solutions to mitigate exposure**. Though fear reduction techniques were employed, these posts received much lower engagement than the simpler posters**. This indicates that increasing direct access to specific and potentially daunting air pollution information via social media is not always effective. Posts linking to the website where further information is available allowed individuals with significant interest to pursue additional information but did not overwhelm viewers who did not possess the same degree of interest.

Ultimately, we recommend that Miljøpunkt does not increase the quantity of informational posts on their social media as it has not been equally effective at engaging viewers. By amplifying the resources on their webpages and providing additional recommended action steps to their viewership they will reduce the chance of overwhelming the target audiences and improve the chance of longer-term interest on the part of the viewer.

7.4 Provide Solutions

The final suggestion for Miljøpunkt in a future environmental media campaign is to provide solutions for individuals to engage in greener initiatives.

After meeting with Mathias Vestergaard Nielsen, we were able to further our hypothesis from research prior, that it is not effective to only use disconcerting information. In terms of environmental issues, especially air pollution, it is often difficult to display information pertaining to its pervasiveness and the negative health effects associated with it in a manner that is not entirely overwhelming. In order to avoid hopelessness and therefore a lack of action and attention, achievable action steps must also be included.

In our conversation with Mathias, he stated that an important balancing act within the municipality's campaign was providing the public with air quality information, without overwhelming them. Therefore, the Copenhagen Municipality campaign focused on three main points: the problem, the consequences, and the *solution.* In addition to focusing on solutions as one of the main talking points, solutions for an individual were also provided in a quiz format. Here, an individual was able to test their knowledge about air pollution, and the conclusion of the test provided the citizen "with good advice to avoid exposure and minimize air pollution."

In our campaign, we also provided a means for viewers to learn more about their contribution and exposure to air pollution, including a QR code linked to the Miljøpunkt website. This proved successful as we were able to quantify the number of times an individual would view the poster, and then take the time to learn more about air pollution and exposure and emission reduction. The number of scans per poster proved that individuals felt inclined to learn more about the issue when the information was provided to them and readily accessible. We were also able to determine that citizens felt inclined to learn more about their exposure levels and strategies to mitigate air pollution by viewing the clear increase in interactions on the Miljøpunkt website.

8. Conclusion

Due to the presence of ultra-fine particles in Indre By and the lack of awareness from residents and commuters in the neighborhoods near The Lakes, it is important to improve understanding of the pervasiveness of particle pollution and its resulting adverse health effects. Despite extensive cycling and pedestrian infrastructure in Copenhagen, particulate matter from vehicles is extremely common in areas of high traffic. Specifically, around the Dronning Louises Bro, one of the most traveled bridges in the greater Municipality.

In order to lessen the clear gap of knowledge between citizens and particulate pollution levels, **our team developed and assessed multi-media strategies to present such information to the public in a clear and engaging manner**. Through observations from our own dissemination, as well as insights from professionals who have worked on media campaigns regarding air pollution in the city, we were able to conclude which approaches were effective to use in future media campaigns.

Through the analysis of audience interaction with the presented media, **four main recommendations** have been provided to Miljøpunkt Indre By & Christianshavn;

- To localize information
- Simplify complex concepts
- Reduce daunting information
- Provide solutions to the target audiences

Each of these strategies works in tandem with the others to create a multifaceted media campaign with an increased chance of success. To effectively disseminate information regarding particulate air pollution, each of these four factors must be considered carefully as small adjustments can result in significant changes to interpretation.

By developing the media campaign, we were able to complete the goal of achieving increased public awareness of particulate pollution. Widespread engagement through the physical copies of the posters, as well as social media posts of the posters and other supplemental material, resulted in a longer viewing duration on the Miljøpunkt website, especially on the pages we created. Within the website, viewers were able to see their contribution and potential exposure to particulate pollution. Therefore, the lengthening stay duration on the website proved that individuals who viewed our media were interested enough to learn more about car-related air pollution.

Although we were not able to conduct the campaign for enough time to observe policy or individual behavioral changes in efforts to mitigate air pollution, **the strategies used in our campaign increased interactions on multiple platforms as well as awareness about particulate pollution**. With the continuation of this media campaign or similar ones to follow, we suggest the implementation of the recommendations above. They have proven capable of heightening engagement around the issue, and in general, contributing to the success of environmental multi-media campaigns.

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Appendices

Appendix A: About the Sponsor

Miljøpunkt was founded in 2012 with the goal of making an impact on the people of Copenhagen and a positive change in environmental policy. They have published articles and newsletters about particulate pollution in the area and encourage locals to make changes to their daily lives that are more environmentally friendly. They have collaborated with multiple universities and helped sponsor student research on the topic of inner-city pollution.

Miljøpunkt aims to support and develop local environmental action. They work in collaboration with city officials in Copenhagen, students, volunteers, citizens, and businesses. Overall, their mission is to "create a better environment and more sustainability in the city" through the facilitation of dialogue within diverse networks.

Appendix B: Informed Consent

We are a group of students from Worcester Polytechnic Institute in Massachusetts, in the United States. We are conducting a survey of local residents to learn more about their perception of environmental information. We believe that this research will provide information that will aid our sponsor, Miljøpunkt Indre By & Christianshavn, in their mission to create a more sustainable and healthy Copenhagen.

Your participation in this survey is entirely voluntary and you may withdraw at any time. Your responses will remain anonymous, and no names or identifying information will be included in project reports or publications.

This project is a collaboration between WPI and Miljøpunkt Indre By & Christianshavn, and your participation is greatly appreciated. If interested, a copy of responses can be provided upon conclusion of the study.

Appendix C: Survey Questions

       To obtain information regarding the commuting habits of our audience in addition to their ability and willingness to alter their commuting strategies we employed the use of a survey. The survey directs contributors to air pollution and non contributors to different follow up questions and redirects them to different pages of the Miljøpunkt website upon completion for further information.

       Do you live in Indre By or Christianshavn?

       Yes

       No

       What mode of transportation do you use most often (ex: going to work)

       Walking

       Biking

       Driving

       Metro/Train/Bus

       Drivers:

       Why is driving your preferred mode of transport?

       Lower cost

       Comfort

       Accessibility

       Other:

       Have you tried other modes of transport? (walking, biking, bus, train etc.)

       If yes, what have you tried?

       If no, why not?

       Non-drivers:

       Why do you choose not to drive?

       What would make your normal commute easier?

Appendix D: First Iteration of Posters

Before going to Copenhagen, our group developed some concept posters for the dissemination of air pollution information. The photos were taken from the creator commons website. The poster has a sentence to attract the reader, and a statement about air pollution, with a QR code to scan that links to the Copenhagen Air Quality Index.
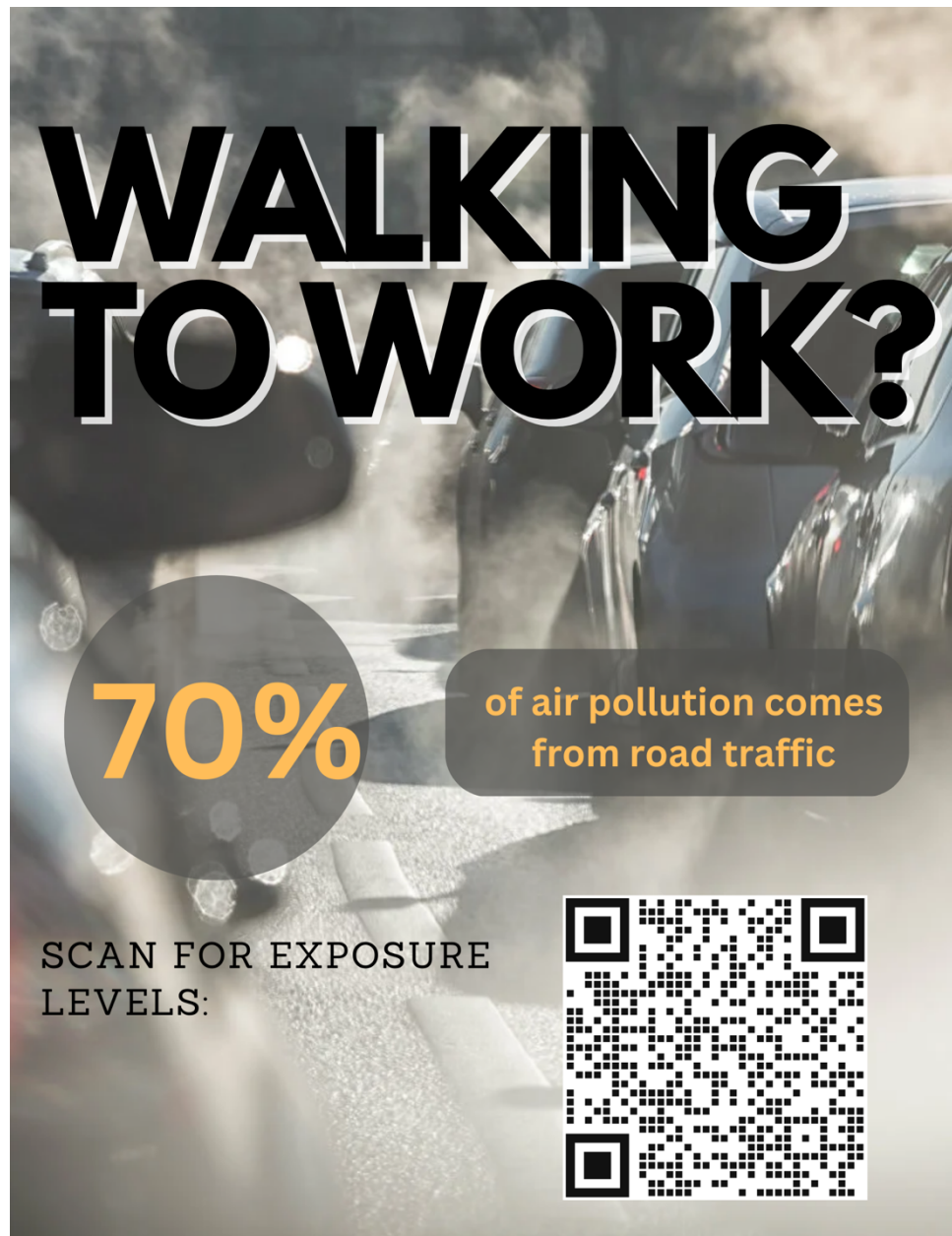

Figure 14: First Iteration of Poster About Driving

Figure 15: First Iteration of Poster About Children

Figure 16: First Iteration of Posters About Cyclists

Appendix E: Second Iteration of Posters

After arrival, the team developed the second iteration of posters following guidance from Miljøpunkt employees. Photos were taken by the intersection of Dronning Louises Bro during rush hour. We also included phrases that would be easier to understand by the viewer.

Figure 17: Second Iteration of Poster About Drivers. It reads, "Are you driving to work? 70% of air pollution comes from road traffic".

Figure 18: Second Iteration of Poster About Children. It reads, "Children Are Susceptible to Air Pollution".

Figure 19: Second Iteration of Poster About Cyclists. It reads, "If you cycle to work, you could be exposed to air pollution!"

Appendix F: Final Iteration of Posters

The final iteration of the posters was developed after consulting with Christian Gaarde Neilsen and the Local Environmental Committee. The posters were all consistant, with a dark green background, the QR Code on the bottom left, and the statement below the picture. The QR Code links to the Miljøpunkt website.

Figure 20: Final Iteration of Poster About Drivers. It reads, "Drivers are more exposed to air pollution".

Figure 21: Final Iteration of Poster About Children. It reads, "Children are more susceptible to air pollution from cars".

Figure 22: Final Iteration of Poster About Cyclists. It reads, "Cyclists are exposed to air pollution from car traffic".

Figure 23: Final Iteration of Poster About Walkers. It reads, "Pedestrians are exposed to air pollution from cars".

Appendix G: Particulate Pollution Data

On the day of April 18, 2023, the group traveled and observed particulate pollution levels at the intersection of Søtorvet and Frederiksborggade during rush hour from 7:41 to 8:40. The data was inputted into the chart below. From left to right, the chart says "Location", "Measurement Period", "Number of Particles per cm^3", "Observations/Traffic Count", and "Weather".

The device that was used measured particle pollution of $PM_{0.1}$, ultrafine particles. PM is particulate matter, a traditional way of assessing particulate pollutants. The device measured the average particle pollution per minute. The team measured air pollution at a height of 1 meter above street level. During that time, the group observed the number of cars, cyclists, and pedestrians going through the intersection. Data was collected from the device using Trakpro, a software that was in the manual of the device. The device is calibrated once a year and was last calibrated in December of 2022. Any highlights in the chart show an anomaly that is more explained in the right column of "Observations/Traffic Count".

Table 1: Ultrafine Particle Concentration Measurements Over One Hour Taken April 18, 2023

Måling af ultrafine partikler (UFP) den 18. april 2023 Ved Dronning Louises Bro

Lokalitet	Måleperiode	antal partikler / cm³			Observationer/trafiktælling		Veir
intersection of Søtorvet and Frederiksborggade	0:27 min (Start at 7:41)	Avg. 16841	Max. 37925	Min. 8651	04/18/2023, 07:41:27, 9403 04/18/2023, 07:42:27, 9599 04/18/2023, 07:43:27, 8651 04/18/2023, 07:44:27, 8676 04/18/2023, 07:45:27, 29205 04/18/2023, 07:46:27, 17091 04/18/2023, 07:47:27, 10798 04/18/2023, 07:48:27, 12904 04/18/2023, 07:49:27, 10987 04/18/2023, 07:50:27, 15685 04/18/2023, 07:51:27, 11686 04/18/2023, 07:52:27, 17963 04/18/2023, 07:53:27, 19515 04/18/2023, 07:54:27, 29646 04/18/2023, 07:55:27, 17920 X 04/18/2023, 07:56:27, 14945 04/18/2023, 07:57:27, 14595 04/18/2023, 07:58:27, 29743 04/18/2023, 07:59:27, 17258 04/18/2023, 08:00:27, 17326 04/18/2023, 08:01:27, 15321 04/18/2023, 08:02:27, 19520	Avg. Amount of pedestrians: 11+/- 5 per 58 seconds at intersection on both sides Cars: 1633 total cars observed Bikers: 8348 in total from east-west and to west-east (total period from two measurements 7:41-8:40)	Sunny, 5 degrees celcius, Wind shift 5-11 km/hr

| | | | | | 04/18/2023, 08:03:27, 37925
04/18/2023, 08:04:27, 15555
04/18/2023, 08:05:27, 14346
04/18/2023, 08:06:27, 14230
04/18/2023, 08:07:27, 14218 | 7:55
X – Smoker in area | |
| intersection of Søtorvet and Frederiksborggade | 0:33 (Started at 8:08) | Avg. 16841 | Max. 37925 | Min. 8651 | 4/18/2023, 8:08:32,12690
4/18/2023, 8:09:32,10640
4/18/2023, 8:10:32,10244
4/18/2023, 8:11:32,9322
4/18/2023, 8:12:32,9263
4/18/2023, 8:13:32,10402
4/18/2023, 8:14:32,9526
4/18/2023, 8:15:32,9048
4/18/2023, 8:16:32,19231
4/18/2023, 8:17:32,9216
4/18/2023, 8:18:32,10738
4/18/2023, 8:19:32,8068
4/18/2023, 8:20:32,15079
4/18/2023, 8:21:32,8474
4/18/2023, 8:22:32,8112
4/18/2023, 8:23:32,8566
4/18/2023, 8:24:32,15737
4/18/2023, 8:25:32,7189
4/18/2023, 8:26:32,5967
4/18/2023, 8:27:32,5880
4/18/2023, 8:28:32,6973
4/18/2023, 8:29:32,5920 | Avg. Amount of pedestrians: 11+/- 5 per 58 seconds at intersection on both sides

Cars: 1633 total cars observed

Bikers: 8348 in total from east-west and to west-east

(total period from two measurements 7:41-8:40) | Sunny, 5 degrees celcius, Wind shift 5-11 km/hr |

					4/18/2023, 8:30:32,15409 4/18/2023, 8:31:32,26640 4/18/2023, 8:32:32,5588 4/18/2023, 8:33:32,6504 4/18/2023, 8:34:32,12148 4/18/2023, 8:35:32,6727 4/18/2023, 8:36:32,5022 4/18/2023, 8:37:32,4671 4/18/2023, 8:38:32,8198 4/18/2023, 8:39:32,5303 4/18/2023, 8:40:32,4386		