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REDUCING AIR POLLUTION IN CITIES: EVALUATE THE GAP IN POPULATION ENGAGEMENT AND POLICY STRATEGIES

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ABSTRACT
Improving outdoor air pollution is a global emerging concern that can be explored in product design education. Polluted air causes not only severe health risks but also negative effects on economics of countries. Urban planning design is a crucial part of the improvement process. However, this process often involves many different interdisciplinary factors. This master's project study focuses mainly on two different approaches to improve air quality: *reduction* of *pollutant emissions* by traffic management strategy and enhances *pollutant dispersion* by *urban planning*. A review highlights the current research on the two approaches, their limitations, and future consideration. To gain richer information through a user-oriented design approach to better understand participants' attitude, a qualitative approach with deep-in digital interviews was used in this study. This study reveals a gap of information between policymakers and users, which decreases the effectiveness of air quality improvement policies.

Keywords: Air pollution, urban design, street canyons, local traffic policies, product design education

1 INTRODUCTION: POLLUTION IS VERY EXPENSIVE
Air pollution is considered as a primary environmental concern worldwide. This issue is especially more serious in cities because of pollutant emissions released from vehicle transportations. As a result, exposure to polluted air can affect negatively to people's health. A recent study estimated that 4.1 million people died associated with poor air quality in 2016 [1]. Another research from O'Donoghue, R.T. (2007) [2] and Quiros, D.C. (2013) [3] further revealed that breathing during walking increases significantly the health risks of pedestrians when compared to other road users. Health risks of air pollution consequently make countries sustain considerable economic costs, including direct medical costs, health care costs, and opportunity costs from diminished productivity of pollution-damaged populations [1]. Therefore, improving outdoor air pollution and harm reduction solutions in city centres are essential to encourage people to switch to sustainable transports such as walking, cycling, or public transport.
To get an overview of air pollution in urban environments, in 2021, the municipalities of Oslo, Bergen, Bærum, Drammen, and Kristiansand, as well as NILU, OsloMet, Telenor, Telia, and Vicotee, collaborate in the URBANITY. This research project includes master's students in product design education and the overall aim is to provide an opportunity to continuously monitor air quality with a low-cost sensors network in the cities. The project will create high-quality real-time air quality maps, providing residents and stakeholders with better information and reliability. The stakeholders hope that upon completion of the project, they will create a platform to improve services to residents, such as personalized air quality information, meanwhile encourage citizen participation in making traffic policies and urban planning.

2 BACKGROUND AND LITERATURE REVIEW: A MATTER OF POLICIES
Numerous studies on reducing air pollution have been conducted on various aspects, including traffic management strategies and urban design strategies. However, this information remains fragmented, mainly focused on specific parts and somewhat technical, which reduces its applicability to local policy or urban development and management plan [4]. A broad literature review reveals a more comprehensive picture, indicating potentials for ongoing research. Meanwhile provides the evidence base for decision-makers in the implementation strategy of clean air policies.

Over the last few decades, the EU has developed clean air policies focus on reducing pollutant emissions. Most local policies have steady attention on air quality improvement by using traffic management strategies (TMS). A review by Bigazzi, A.Y. [5] indicates their policies focused mainly on two primary mechanisms:

The total amount of vehicle kilometres travelled: primarily affected through travel activity and mode choice modifications such as using public transportation, reducing private car usage, increasing parking fees, shared-ride programmes, telework, etc.

Average emissions rates: affected through vehicle and fuel characteristics and driver behaviour modifications like ring road utilization, odd-even driving, speed limit reduction.

Bigazzi has reviewed numerous identified studies to evaluate the state of evidence that TMS can improve urban air quality for exposed populations. Only 7 of the 22 studied strategies have limited evidence of effects on air quality. While other TMS strategies do not have sufficient evidence of its impact [5]. Besides, some TMS strategies are also associated with the risk of negative effects or opportunities for spill over and indirect effects.

On the other hand, recent air quality mappings in several cities in Europe such as Paris [6], London [7], and Antwerp [8] indicated city street canyons have levels of air pollution (NO_2) nearly as high as highways and ring roads, despite lower traffic intensity. Therefore, more attention has been driven towards passive methods in using natural ventilation to enhance pollutant dispersion and reduce pedestrian exposure to air pollutants among researchers, urban planners, and policymakers.

These studies spread from city-wide scale [9] to local scale such as street canyons in the city centre [4]. Many studies have demonstrated that urban morphology on a large scale affects atmospheric pollution dispersion. Although this phenomenon is still underexplored, significant progress has been recently made in the field.

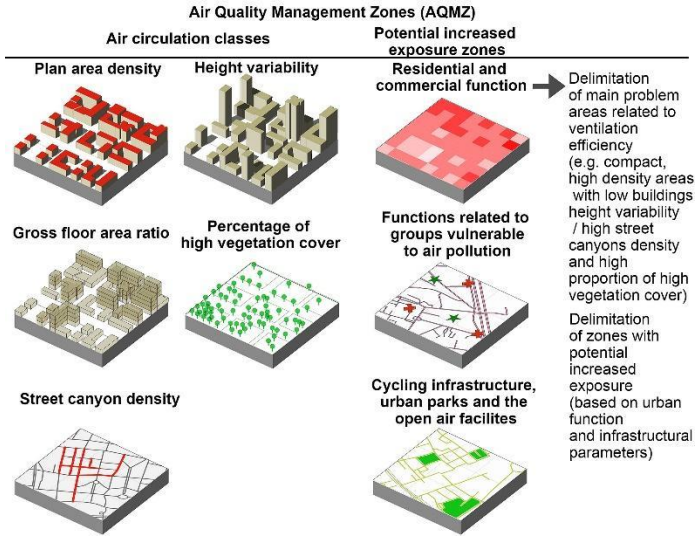

Figure 1. The set of indicators for the Air Quality Management Zones [9]

The gain is the same as studies on a local scale in the city centre. In most urban environments, the city centre area is defined by street canyon configuration, building configuration, the in-canyon configuration [4]. This study aims to describe the general effects of urban morphology on the dilution and dispersion of airflow and pollution. Researchers could have a visual diagram of these different parameters.

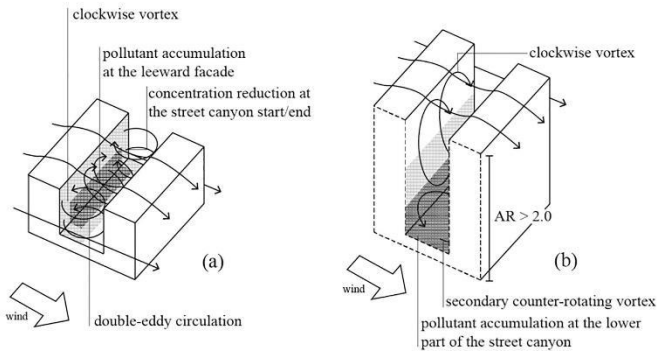

Figure 2. Estimated airflow and pollutant distribution [4]

3 RESEARCH QUESTION: NEW PARADIGM IN THE WAY MAKING POLICIES

Studies on the efficiency of LEZs [10] [11] [12] in the last couple of years have all concluded that results are uncertain. Moreover, research by Boogaard, H. et al. (2012) [13] and Ku, D. et al. (2011) [14] shows that local transport policies, including LEZs, only achieve low results in reducing traffic-related air pollution. In other words, the effects might be possible, but the evidence of benefits is insufficient [5]. Therefore, a different approach is needed. It is essential to planning urban which allowing the wind to flow around the building and disperse traffic air pollution. Those street canyons restrict vehicle emissions diffusion and aggravate roadside air quality. However, this issue is often unnoticed by stakeholders, architects, designers, and the public in city planning due to lack of information. This matter leads to the research question in this study: *How to evaluate gap in population engagement and policy of clean air development strategies in traffic management and urban planning?* The scope of this topic concerns a wide range of interrelated disciplines. In particular, the design process demands both understanding of core urban morphology features (e.g., gross floor area ratio, plan area density, and frontal area density) and the involvement of stakeholders in urban planning. Stakeholders can be categorized into regulators, producers, and users. An analysis of stakeholders can gain a different perspective in improving urban air quality. Due to limited time and resources, this pilot master project focused on only analysing public awareness about local policy examination.

4 METHODS: LITERATURE REVIEW AND QUALITATIVE APPROACH

The research methods used in this review were introduced in the book Research Design by Leavy, P. [15].

4.1 Qualitative approach

This review applies the qualitative method through deep-in digital interviews. The interview consisted of a set of questions about the participants' interest and engagement in urban air quality, then determined the level of willingness to participate in city air pollution reduction programmes. This approach allows having back-and-forth dialogue with respondents, which results in collecting richer information and better understanding the respondents' opinions. Based on the largest age group in Oslo, the participants were chosen from 19 to 44 years old with higher education.

4.2 Design of interview

The interview was designed to follow three main categories and variables associated with each category. Table 1 shows an overview of categories and their variables.

Potential exposure to air pollution: This category determines the targeting of respondents. The respondents should involve in outdoor activities in order to move forward to other questions in the other two categories.

Engagement of population to air quality issue: This category can reveal a better understanding of the respondents' perception and their attitude towards air quality and improving air quality.

Willingness to participate in measures for air pollution reduction: This category provides behavioural patterns that may affect urban policies in improving air pollution in city centres.

Table 1. Category of analysis

Category	Variable
Potential exposure to air pollution	Exposure time
	Activity types during exposure
Engagement of population to air quality issue	Perceptions of air pollution
	Perceptions of air quality information
	Engagement in improving air quality
Willingness to participate in measures for air pollution reduction	Measures in traffic management strategies (TMS)
	Measures in urban planning

All participants were selected based on their outside time and their variety of outdoor activities in the city centre. The majority of members spend more than 6 hours per week outside, high potential of exposure to air pollution.

Activity type results in a wide range of outdoor activities such as walking, cycling, or staying outside. More than a half ratio related to high breathing rate activities. The average inhales weight of pollutants of pedestrians and bicyclists having high breathing activities is higher than the average value observed from commuters [2]. That indicates that interviewed group is a potential due to the increased risk inhale weight of pollutants.

5 RESULTS AND DISCUSSION

5.1 Engagement of population to air quality issue

Perceptions of air pollution: All positive feedback on the need to have air quality information available. The results of the in-depth interviews showed similarities in their perceptions of air pollution. The majority of the students rated the air quality as good. It may be due to the similarity of the group of students in terms of age and living environment. However, that similarity also reflects the monotony of information about air pollution. At the same time, their definition of bad or polluted air is very vague and general.

Perceptions of air quality information: The majority will consider changing their behaviour based on air quality information. In that, air quality has a substantial impact on half of them. However, information about air quality is hard to find in instant smartphone apps or PC desktops. People need to access a specific website (https://www.iqair.com/) or smartphone apps (Air visual) to look for information. This inconvenience also prevents the dissemination of information about air quality. Therefore, people tend to use their senses to judge air quality without using any factual information.

Air quality impacts people's daily activities, especially for vulnerable people such as children, the elderly, and people with a history of respiratory disease. There is a need for citizens to have air quality information available.

In 2018, a pilot project from Castell, N. had deployed low-cost sensors to monitor air quality in kindergartens in the Oslo area to help parents and kindergarten staff change practices accordingly. Although some promising results have been achieved from that, the quality of the data is still questionable [16]. The real-time environmental data at high spatial and temporal resolution need more time to develop.

Similarly, most of the current local activities are heavily related to transport management evaluation and still lack of area morphology consideration, both in terms of city wide-scale and local scale. Each city has a different morphology, such as gross floor area ratio, plan area density, and frontal area density that will strongly impact on air circulation level. At the same street canyon, placing the sensor in an area with good ventilation will give false-positive results. Conversely, when setting sensors at points of accumulation, the data will give false negative feedback. Evaluating studies on a smaller scale help identify sensor locations that fully reflect the air quality in that area, avoiding inaccurate sensor information from local interference.

5.2 Willingness to participate in measures for air pollution reduction

Measures in traffic management strategies: the result shows that all interviewees are willing to cooperate in air quality improvement policies from moderate to high levels.

However, agreement levels with increasing fees in using private vehicles are not supported by interviewees at most measures, especially compared with increasing public transport. Despite the high level of willingness from participating in policies and a high impact of air quality in behaviour, people still do not want to pay extra money for toll fees or convert to greener vehicles. The reason for it may generate from the fact that insufficient evidence of effectiveness for convincing citizens to accept that policy.

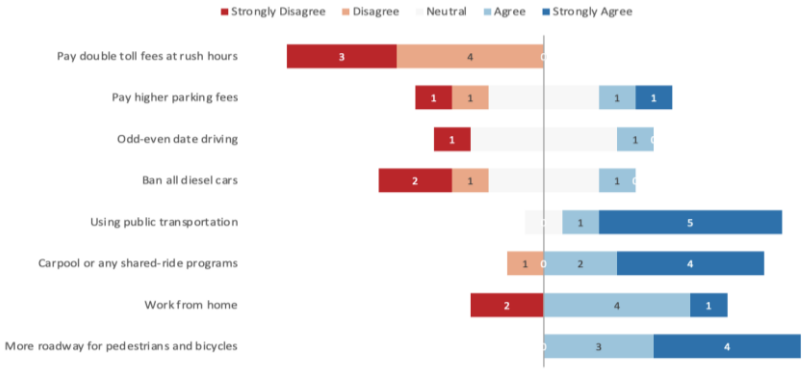

Figure 3. Respondents' opinions about solutions for improving outdoor air quality-TMS policies

However, the assessment from the target in these measures is still based on subjective experiences and not on objective research results. Such ambiguity can explain the lack of air quality improvement reports with solid evidence for each measure, including TMS and urban design. effective evidence-based measures based on Bigazzi's research can be cost-based measures, including increased toll fees and parking, especially for diesel vehicles [5].

Figure 4 shows a high agreement level; however, the low awareness level of the interview group regarding the effect of urban design on air pollution reduction despite the group background.

For example, the solution of planting tall trees in polluted areas is chosen by most students. Still, that measure is not recommended because tall trees will obstruct the wind in diffusing pollution, and the green wall on the building façade does not have a noticeable result in dispersion air pollution [4].

Such misunderstandings can show a lack of sufficient information to raise public awareness of effective measures to improve air quality.

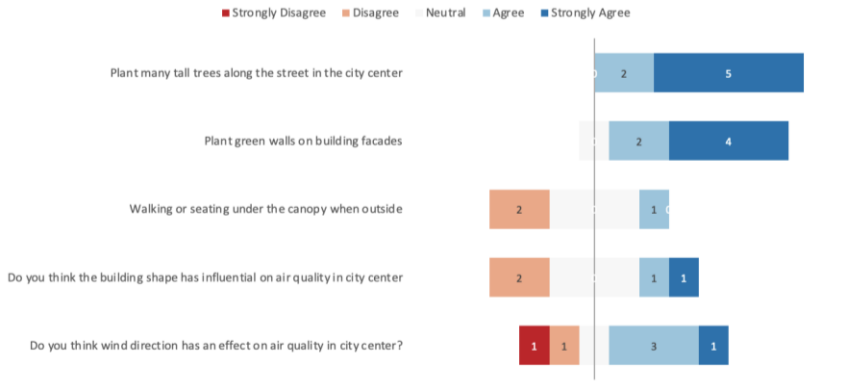

Figure 4. Respondents' opinions about improving outdoor air quality – Urban Design policies

6 CONCLUSIONS

There is a massive gap between the policymakers on improving air pollution and the citizens. The lack of information on air quality will reduce the level of cooperation with policymakers on these issues. In addition, decision-makers themselves need tools to measure the effectiveness of their policies. Creating a platform is absolutely essential. On that platform, the policymakers can adjust their decisions based on quick and timely information, and the people also benefit from this information. This information will strengthen people's support for measures to reduce air pollution emissions to the government.

However, as this pilot master study has shown, measures of the effectiveness of TMS are either completely unproven or very weak. The reason is that there are too many external factors affecting the

measurement process. Especially in the complex urban context, it is easy to be biased. The information that can be received may be too local or to spread to reflect the data accurately.
Frameworks and guideline diagrams for ventilation to reduce pollution have been studied on an urban scale, and the smaller central scale is a big step forward. It contributes to standardize data collection for the system to evaluate the measures applied, the synchronization platform between different strategies. In addition, it provides stakeholders with more parametric tools to deploy strategic studies to measure air indicators and have more foundation for implementing further studies. These strategic studies eventually enable stakeholders such as architects, designers, policymakers, and citizens to have a better foundation to promote the contribution of ideas to develop measures to improve air quality.
However, the studies on transport strategy and urban design still have technical limitations that need further investigation. The improvement of the cheap sensor is necessary. In addition, further studies on the parameters of meteorology and the natural urban environment are required to increase the reliability of the data.
It is worth noting that efforts from the policymakers are not enough. Citizens need to be more active in looking for information and increasing their attention to air quality. That will promote citizen's contribution to the development of improving air quality policies.

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