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# A DYNAMIC ACTIVITY-BASED MODELLING APPROACH TO ESTIMATE EXPOSURE TO AIR POLLUTION: SOME RESULTS OF RECENT EXPERIMENTS IN COPENHAGEN, DENMARK

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**Abstract**: This work reflects the recent and on-going experiments to study individuals' time-activity patterns. The experiments are being conducted to develop a dynamic activity-based modelling framework to estimate subjects' activity-based personal exposure to air pollution. The first experiment was based on a walking activity towards Copenhagen lakes and back on 4 February 2019. Air pollution levels ($NO_2$, $PM_{10}$, $PM_{2.5}$) were modelled along the walking path using the AirGIS exposure modelling system. The second experiment was based on measuring pollution using low-cost air pollution sensor nodes along the lakes on 25 – 29 November 2019. Results showed that the AirGIS predicted the dynamic exposure to air pollution in a satisfying manner. Concerning experiment 2, the measured pollution was relatively higher on the side close to the road, compared to the side close to the lake. The presentation will reflect on more results, relevant details, outlook as well as strengths and limitations of the study.

***Key words: Air pollution, activity-based exposure, micro-environments, AirGIS, experiments, low-cost sensors***

## INTRODUCTION

The health effects of air pollution exposure are well-documented, e.g. cardiovascular disease (Kim et al., 2020). On the other hand, considering only address or work locations as a proxy for pollution exposure may lead to exposure misclassifications (Yu et al., 2018). This is because individuals, in reality, spend a significant amount of time outdoors, e.g. exercising or commuting to work, in urban microenvironments. In addition, pollution levels can vary substantially, not only from location to location, but also over the day, week and seasons (Borge et al., 2019). Therefore, it is indispensable to consider activity patterns of the individuals, which not only enables microsimulation of the same, but also dynamic or activity-based exposure assessment of air pollution.

The Danish AirGIS (Khan et al., 2019a), GIS-based air pollution and human exposure modelling system, is a standard toolkit to estimate air pollution at any location in Denmark. It is a well-validated system (see Khan et al., 2019a for system validation), and is routinely used to facilitate air quality mapping and Danish and international health-related studies.

The AirGIS system has been under an update process to take into account the time-activity patterns of the individuals. The aim is to estimate dynamic exposure to air pollution in urban microenvironments. This paper supplements the previous study (see Khan et al., 2019b) and provides further updates (on-going and recent experiments) of the work in progress.

## MATERIALS AND METHODS

The study site is based on Copenhagen lakes and their surroundings. It is a popular area of the Danish capital with several activities (e.g. exercise, recreational activities) throughout the year (Figure 1). There are also busy roads along the lakes. To study individuals' dynamic exposure to air pollution, we previously performed experiments, where a walking-based activity was undertaken on 4 February 2019. The walk started from the central station of Copenhagen to the lakes and back (Figure 1). Throughout the

whole activity, the location was tracked via an app, OSMTracker for Android and air pollution was modelled. The air pollution ($NO_2$, $PM_{10}$, $PM_{2.5}$) was modelled using the AirGIS exposure modelling system (see Figure 2). The detailed system operation is provided in Khan et al. (2019a) and will not be repeated here. In short, the system works at three different spatial levels of pollution, regional, background and street-level, and can estimate pollution levels at any location of interest.


Figure 1: (a) The Copenhagen lakes and their surroundings (b) Experiment 1: A walking activity from Copenhagen central station to the lakes and back (4 February 2019).


Figure 2: The block diagram of dynamic air pollution exposure modelling framework being implemented in the AirGIS system.

Another experiment was performed on 25 – 29 November 2019, where volunteers measured the pollution levels along the lakes using low-cost air pollution sensor nodes (a repeated measures activity between 10 am and 6 pm). There are two running/walking tracks along the lakes, one close to the road and the other close to the lake. Pollution was measured on both sides, and it was hypothesized that pollution levels close to the road are higher. Figures and other relevant details, e.g. measurements set up, sensor nodes, will be discussed in the presentation.

**RESULTS AND DISCUSSIONS**

Figure 3 shows the modelled pollution levels along the walking path (experiment 1) for one of the pollutants, $NO_2$. As expected, the modelled pollution is higher on one side of the road compared to the other side. This is because of elevated traffic conditions on one side of the road. Thus, AirGIS estimated the pollution levels satisfyingly. Further results will be presented and discussed in the presentation.

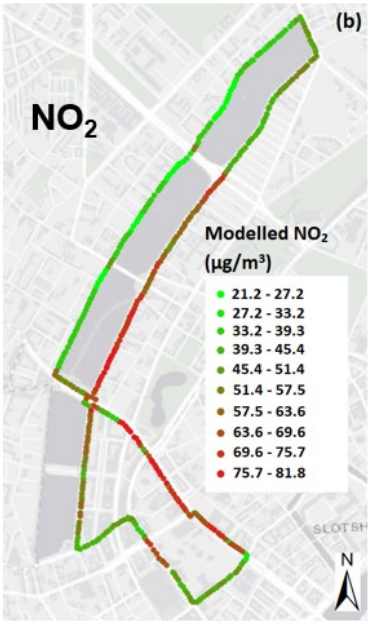


Figure 3: Modelled pollution ($NO_2$) along the walking path (experiment 1).

The results of experiment 2 (will be shown in presentation), measuring pollution levels using sensor nodes along the two walking/running tracks of the lakes, revealed the pollution values were higher along the walking track close to the road, compared to the track close to the lake. This is expected since traffic is the main source of pollution, particularly, within few meters from the road centerline.

One of the challenges of this work is to validate the AirGIS dynamic exposure estimates. Since validation is usually performed via standard, high-quality, static monitors, it will be interesting to compare AirGIS pollution estimates with values measured with the low-cost sensor nodes.

## CONCLUSIONS

The Danish AirGIS system is being updated to take into account individuals' time-activity patterns to estimate their dynamic/personal exposure to air pollution. In a series of previous and ongoing experiments, the AirGIS system performed well in estimating dynamic exposure to air pollution.

One of the challenges is to validate the dynamic exposure estimates since validation is usually performed via high-quality, standard monitors. It will also be interesting to compare AirGIS estimates with pollution values measured via low-cost sensor nodes.

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