MOBILITY POLICY AND AIR QUALITY

THE EFFECT OF A NEW BIKE LANE AND COMMUNITY SPACE ON AIR POLLUTION: A REAL-WORLD EXPERIMENT IN BERLIN

Erika von Schneidemesser, Seán Schmitz, Alexandre Caseiro

IASS POTSDAM
BERLIN
Senatsverwaltung für Umwelt, Verkehr und Klimaschutz
Bezirksamt Friedrichshain-Kreuzberg Berlin
EARTH SENSE

INTRODUCTION

Air pollution exposure in urban areas is a threat to human health. One of the largest sources of air pollution in urban areas is vehicles. This is particularly true for nitrogen dioxide (NO_2) and underlines the need for a shift away from motorized individual transport toward healthy, sustainable transport. The paradigm shift - the *Verkehrswende* or *Mobilitätswende* (Traffic Transition or Mobility Transition) - as it has come to be called, has enjoyed broad support from citizens and decision-makers alike for decades, yet remains largely unrealized. Berlin was the first city to pass a *Mobilitätsgesetz* (Mobility Act). This law has many provisions to expand infrastructure for sustainable transport, such as supporting more cycling infrastructure, prioritizing cycling, walking, and public transit, and overall a more liveable, accessible city.

To understand the effect of mobility policy on air quality, real-world experiments provide an opportunity to quantitatively assess the effect of such infrastructure changes on air quality. Here we found that the implementation of a bike lane reduced the concentrations of nitrogen dioxide that cyclists are exposed to. Furthermore, the small-scale repurposing of street space through a temporary *Spielstrasse* (community space) which closed a section of a street to vehicles to open the space for the community, also reduced air pollution during the occurrence of the community space. Such quantitative assessments of urban mobility policies can provide valuable information for policy decisions.

AIR POLLUTION EXPOSURE WHILE CYCLING

The implementation of the bike lane reduced the exposure of cyclists to air pollution (NO_2) when cycling on Kottbusser Damm by 8.7 ± 5 µg m^{-3} or 22 % (see Figure 1).

The change in NO_2 concentrations that cyclists are exposed to in the presence of a protected bike lane compared to riding on the street with no cycling infrastructure was assessed using mobile measurements. An air quality sensor was installed on the handlebars of a bicycle and a prescribed route (see Figure 3) was cycled numerous times before and after the implementation of the bike lane.

Overall, NO_2 concentrations decreased by 10 µg m^{-3} during the measurement period. The analysis of the normalized values[1] showed that 8.7 µg m^{-3} of this can be attributed to the installation of the bike lane.

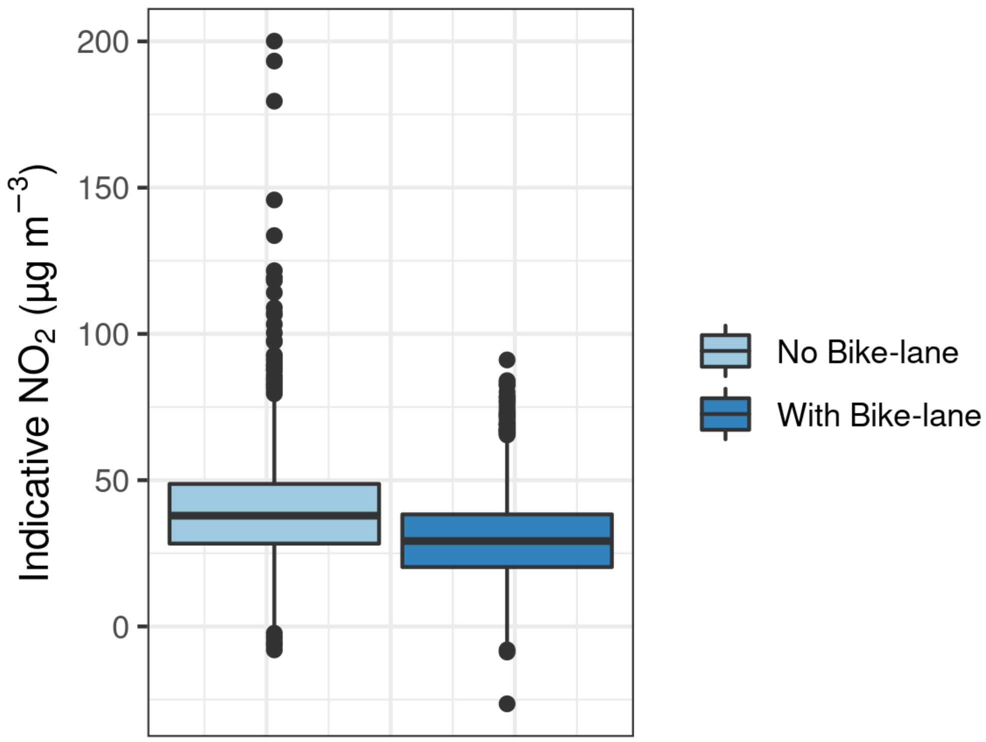

Figure 1. The change in indicative[1] NO_2 concentration that cyclists were exposed to before and after the implementation of the bike lane.

[1] See Analysis Notes on p. 7.

AIR POLLUTION AND A COMMUNITY SPACE

During the periods when Böckhstrasse was temporarily converted into a community space, the concentration of NO_2 was reduced by 10 µg m^{-3} compared to the periods when vehicles were allowed on the street. However, our analysis[2] indicates that only 3.7 µg m^{-3} or 16% of this can be attributed to the implementation of the community space (see Figure 2).

To quantitatively estimate the effect of closing the street to vehicle traffic for the community space, an air quality sensor was installed on the 1st floor façade of Lemgo Elementary School, in the area where the community space occurs (see Figure 3). Measurements were made throughout 2020, in months with and without the implementation of the community space (i.e., closure to vehicular traffic). The changes were measured by comparing the concentrations during the implementation of the community space (Wednesday, 14:00-18:00) with the concentrations on Wednesdays where no street closure occurred.

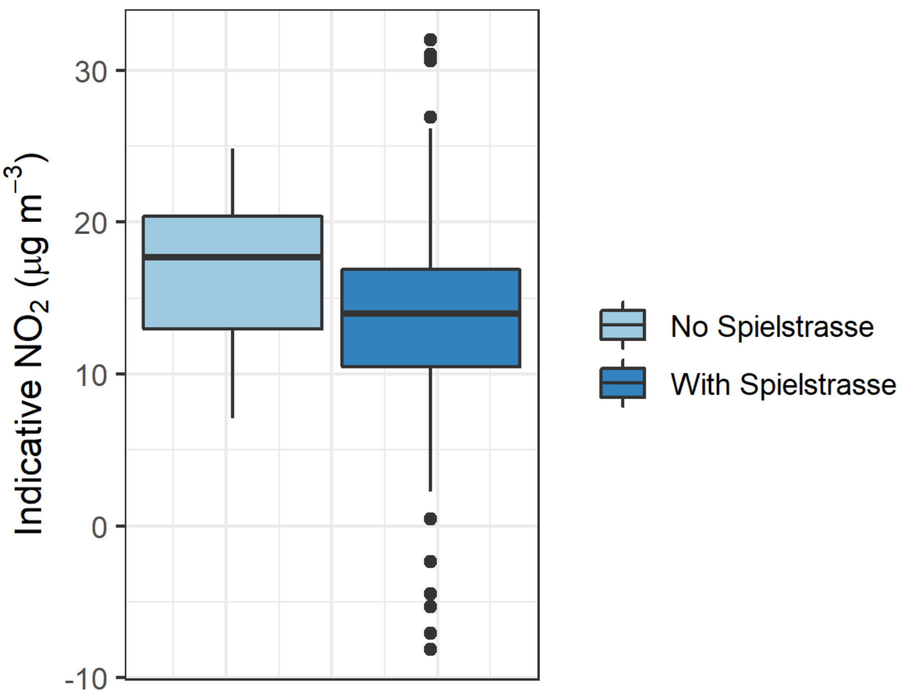

Figure 2. The change in indicative[2] NO_2 concentrations during the occurrence of the community space compared to the same day and time without the occurrence of the community space.

[2] See Analysis Notes, p.7.

AIR QUALITY ON KOTTBUSSER DAMM

It was not possible to discern any effect of the community space or the implementation of the bike lane on the NO_2 air pollution concentrations on Kottbusser Damm overall.

Air quality sensors were installed in five locations on Kottbusser Damm (see Figure 3), both to accompany the mobile measurements and to assess any potential larger scale changes in air quality on Kottbusser Damm owing to the infrastructure changes. Due to the broad range of factors influencing air quality on the street overall, no statistically significant effect could be determined and attributed to the implementation of the bike lane.

BACKGROUND

Air quality measurements were started in early February 2020 on Kottbusser Damm and Böckhstrasse in Berlin. The original intention was to perform before and after measurements associated with the reallocation of street-space that would introduce a bike lane onto Kottbusser Damm. Furthermore, the measurements on Böckhstrasse were intended to assess the effect of the community space on air quality. The location of the air quality measurement sensors is shown in Figure 3. In addition to the stationary measurements, mobile measurements by bicycle were carried out to investigate the effect of the bike lane implementation on the concentration of air pollution cyclists are exposed to (Figure 3).

Owing to the COVID-19 Pandemic, the intended plans were not able to be carried out as designed but were adjusted to accommodate the changes. The bike lane was implemented as a pop-up bike lane on April 22 and 23, rather than later in the summer, as was originally planned. The implementation of the community space did not change and from April 1 through September 30, the Böckhstrasse was transformed into a temporary, open community space for adults and children in the neighborhood between 14:00 and 18:00 on Wednesdays and closed to vehicle traffic.

The air quality sensors used were EarthSense Zephyrs. The analysis here focuses on the air pollutant nitrogen dioxide (NO_2), as its source in urban areas is dominated by vehicle traffic and the changes would have the largest impact on traffic patterns.

Air quality measurements were concluded in October 2020.

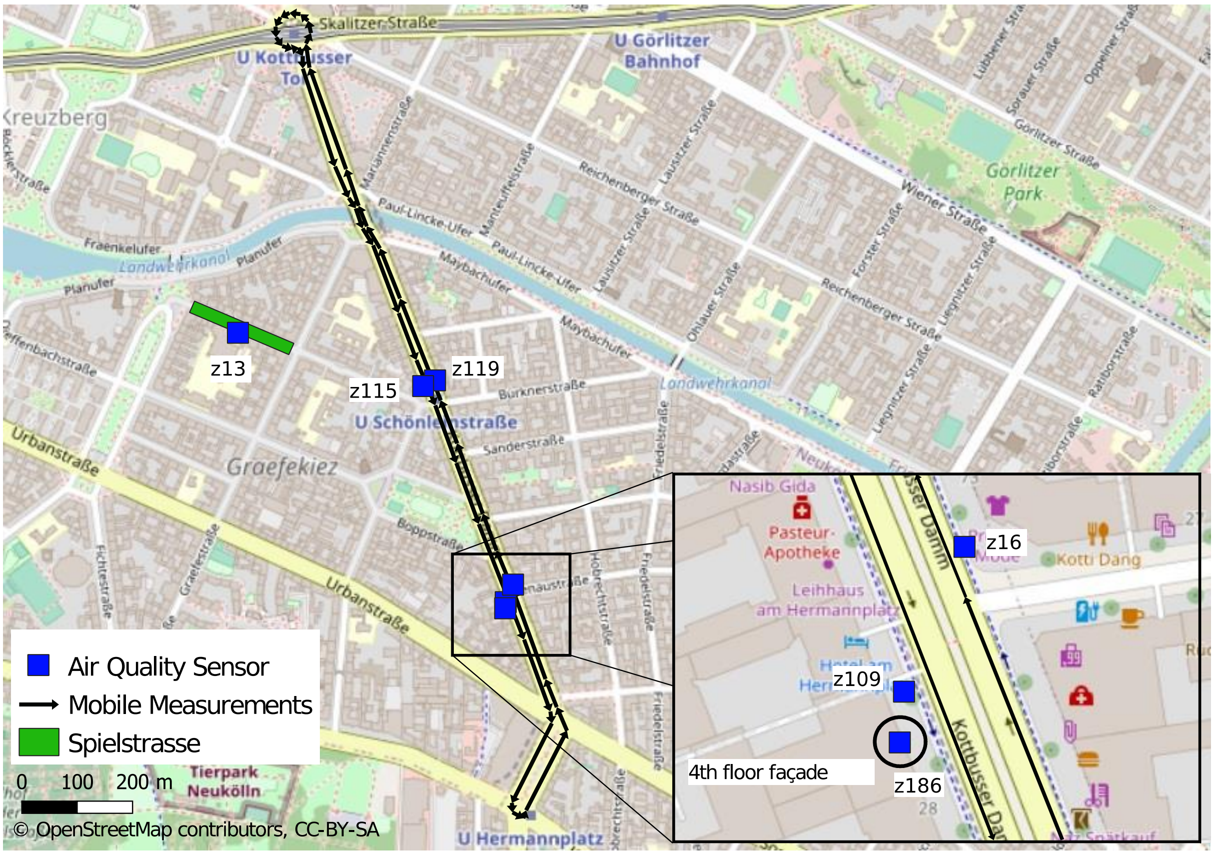

Figure 3. Air quality measurements on and around Kottbusser Damm. The stationary air quality sensors (blue squares) were mounted on lampposts or building facades. Sensor z13 was located on the 1st floor façade of the Lemgo primary school.

ANALYSIS NOTES

To account for changes in emissions, especially in the case of COVID-19 lockdown policies which in some cases drastically changed vehicle traffic patterns, and meteorology, which has a substantial impact on air quality, all mobile measurement values were normalized to the Kottbusser Damm stationary measurements. For the evaluation of the stationary measurements, these values were normalized to an average of urban background concentrations from four urban background monitoring stations maintained by the city of Berlin. This normalization is a method through which measurements made at different times and under different conditions can be compared. To clearly communicate what the observed changes were, the normalized values were adjusted using the median of the hourly mean NO_2 values over the entire time period analysed to present an indicative concentration that reflects real-world concentration levels.

The differences in concentrations between the absence and presence of the bike lane and absence and presence of the community space were tested for statistical significance using the Wilcoxon-Mann-Whitney U-Test. In both cases the differences were statistically significant.

It should be noted that in the case of the bike lane measurements, the measured difference on Kottbusser Damm was also observed along the short Kottbusser Tor and Hermannplatz sections of the route, where there was no cycling infrastructure change. It is unclear why this difference exists there as well.

Additionally, mobile measurements that were conducted simultaneously on the side streets were analysed and the change observed on Kottbusser Damm did not exist there. In that sense, the change on Kottbusser Damm is real, the methods used are sound, and from the available data, the change in air pollution exposure was attributed to the bike lane. There are a number of possibilities that could explain the similar change on the short sections where there was no infrastructure change, including but not limited to, circumstances separate or connected to the implementation of the bike lane that influenced the concentrations at Kottbusser Tor and Hermannplatz, residual effects related to response time of the sensors under mobile conditions. This is under further investigation.

SUMMARY

A real-world experiment was carried out to quantitatively assess the changes in air quality owing to the implementation of a bike lane on Kottbusser Damm, as well as the temporary, recurring community space on Böckhstrasse in Berlin.

- The measured reduction of the mean NO_2 concentration to which cyclists were exposed on Kottbusser Damm was 10 µg m^{-3}, of which 8.7 µg m^{-3} could be attributed to the establishment of the bicycle lane.
- The measured reduction of the mean NO_2 concentration in Böckhstrasse was 10 µg m^{-3}, of which 3.7 µg m^{-3} could be attributed to the community space.
- An influence on the NO_2 pollution at Kottbusser Damm as a whole owing to the community space or the installation of the bike lane could not be determined.

The annual limit value for NO_2 concentrations is 40 µg m^{-3}. Health studies often use urban background stations as indicators of population exposure, while EU directives require that air quality be measured at locations where the highest concentrations are expected to occur - which includes major roads. Although mobile measurements are more representative of traffic locations due to their proximity to traffic emissions, the reductions observed during the real-world experiment have strong health relevance. More such measurements are needed to understand the real-world effects of mobility measures on air quality and the representativeness of such results.

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Contact:

Erika von Schneidemesser (evs@iass-potsdam.de; 0331 288 223348)

Address:

Berliner Straße 130

14467 Potsdam

Tel: +49 (0) 331-28822-340

Fax: +49 (0) 331-28822-310

www.iass-potsdam.de

ViSdP:

Prof. Dr. Mark G. Lawrence,

Managing Scientific Director

18.02.2021

GEFÖRDERT VOM

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