Commute exposure to ultrafine particles - Measurement approaches and investigation of exposure determinants

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Background

A better understanding of exposure to ultrafine particles (UFP) in different transport microenvironments and the determinants is crucial for epidemiological exposure assessments as well as for policy intervention considerations.

Aim

Our study aims to explore variations in personal exposure to UFP between five modes of transportation (bus, tram, car, walking, bicycle) and urban locations in the area of Basel, Switzerland. Additionally, the quantitative contribution of commuter exposure determinants such as meteorological, traffic, route and temporal parameters is investigated.

Methods

Personal measurements to UFP are carried out between January and August 2011 based on three approaches. Firstly, samples in different transport microenvironments are collected along two pre-defined routes (Approach 1). The routes cover different areas of the study area such as urban background, city centre and suburban areas. Measurements are taken twice a month on a Wednesday and Thursday morning in three seasons. Secondly, repeated measurements in various modes of transport on the same route are carried out (Approach2). Samples are collected in five modes in three time slots: weekday rush hour, weekday non rush hour and weekend. During a measurement day, samples are collected four times (twice in each direction) for each mode and each time slot. The length of the route (class 1 main road) is 2.6km. Finally, the contribution of commute exposure to total daily exposure as well as the influence of the route in the commuter's personal exposure is explored (Approach 3). In particular, we investigate the effects of choosing high (mainly main roads) and low exposure routes (avoid main roads) in urban streets when commuting by bicycle between home and work place. 24h measurements are currently carried out by one person during two weeks per season. A portable miniature Diffusion Size Classifier (miniDiSC) is used to measure particle number concentration and average particle size in the range of 10 to 300nm. In addition, PM2.5 is measures with a personal data ram (pDR).

Results

Preliminary results of approach 2 show that the personal in-transit exposure to UFP is generally higher during rush hours than outside rush hours. UFP levels seem to be higher in active modes (30'000-40'000 p/cc) than in public transport (22'000-27'000

p/cc). In addition, much variation in exposure was found for the active modes, especially for bike, indicating the relevance of potential exposure determinants. The lower exposure levels in the bus compared to the tram are related to air condition and closed windows. During weekends, the exposure levels were similar for all modes. The average particle size in transit was between 40 and 60nm.
Mean UFP exposure levels of the 24h measurements (Approach 3) at home and at work were ~6'000p/cc in winter and spring. The general commute exposure of the 24h measurements was found ~37'000 p/cc. The mean travel difference of green (26min) and fast route (23min) was only 3 min due to red lights along the fast route. Avoiding main roads when traveling by bike to work seems to reduce the commute exposure by one half in the city of Basel.

Conclusion

The first results indicate an effect of mode, time of day and week as well as road characteristics on commute exposure. Personal UPF exposure levels during bicycle commuting were ~6 times higher than at home or work. Measurements are ongoing and the results will be refined. Exposure determinants will be quantitatively defined using various statistical methods.

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Commute Exposure to Ultrafine Particles

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Introduction

A better understanding of exposure to ultrafine particles (UFP) in different transport microenvironments and the determinants is crucial for epidemiological exposure assessments as well as for policy intervention considerations.

Aims

To investigate the
- personal exposure to UFP in different transport micro-environments
- quantitative contribution of potential exposure determinants
- contribution of commute to daily UFP exposure

Measurement approaches

Personal exposure measurements are carried out based on 3 approaches (A1-3) in the region of Basel, Switzerland, from Jan-Aug 2011. During the measurements, a protocol on meteorological, temporal, traffic and route parameters is filled out.

A1: Comparison of urban areas: 2 routes with pre-defined modes through the study area

A2: Comparison of 5 modes (walking, bike, bus, tram, car) on same route: 3 time slots: weekday rush hour, weekday non-rush hour, weekend (*route: 2.6km, class 1)*

A3: 24h measurements: Comparison of fastest route *(mainly main roads; 2.5km)* and "green" *(avoid main roads; 2.9km)* bike commute route

Measurement Devices

MiniDiSC:	Particle number concentration & average particle diameter (10-300nm)
Personal data ram:	Continuous & filter based PM2.5
HOBO:	Temperature & relative humidity
GPS	Speed, time, geographical position

Fig. 1: MiniDiSC

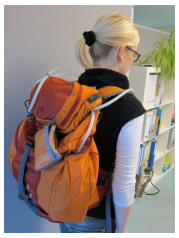

Fig. 2 & 3: Personal sampling setup

Results

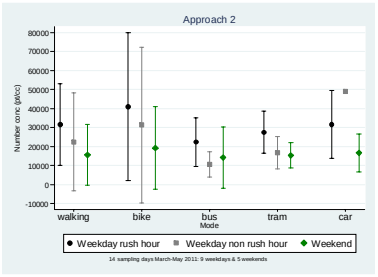

Fig. 4: Avg. particle number concentration (+/- SD) by mode and time slot

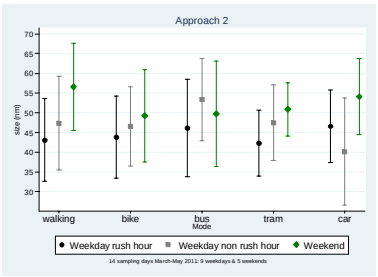

Fig. 5: Avg. particle size (+/- SD) by mode and time slot

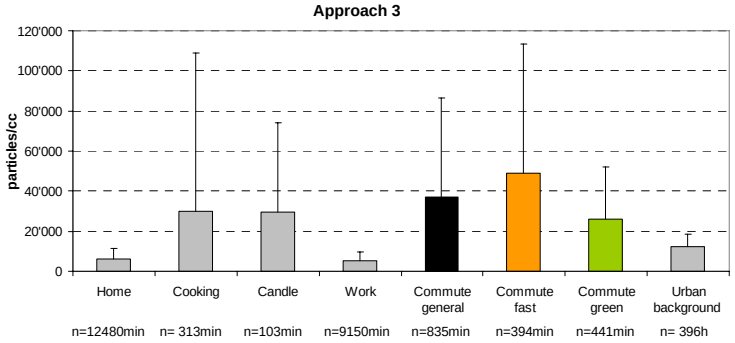

Fig. 6: Avg. particle number conc. (+ SD) of 16 24h measurements (Jan-May 2011)

A2: Preliminary results show that the personal in-transit exposure to UFP is generally higher during rush hours than outside rush hours. UFP levels seem to be higher in active modes (30'000-40'000 p/cc) than in public transport (22'000-27'000 p/cc) (Fig 4). In addition, much variation in exposure was found for the active modes, especially for bike, indicating the relevance of potential exposure determinants. The lower exposure levels in the bus compared to the tram are related to air condition and closed windows. During weekends, the exposure levels were similar for all modes. The average particle size in transit was between 40 and 60nm.

A3: Mean UFP exposure levels at home and at work were ~6'000p/cc in winter and spring (Fig.6). The general commute exposure of the 24h measurements was found ~37'000 p/cc. The mean travel difference of green (26min) and fast route (23min) was only 3 min due to red lights along the fast route. Avoiding main roads when traveling by bike to work seems to reduce the commute exposure by one half in the city of Basel.

Conclusions & Future Work

- The first results indicate an effect of mode, time of day and week as well as road characteristics on commute exposure.
- Personal UPF exposure levels during bicycle commuting were ~6 times higher than at home or work.
- Measurements are ongoing and the results will be refined. Exposure determinants will be quantitatively defined using various statistical methods.

This study is part of the European project "Transportation, Air Pollution, and Physical Activities (TAPAS)"; an integrated health risk assessment program of active travel policies. It is coordinated by the Centre for Research in Environmental Epidemiology (CREAL) in Barcelona.

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