Preliminary Results from the Evaluation of the Impact of Bioethanol Buses on Urban Air Quality

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Introduction

The change from fossil fuels to biofuels in transport as a measure to control greenhouse gas emissions may create new environmental challenges as the emissions of other harmful pollutants may increase. High emissions of acetaldehyde, formaldehyde and acetic acid have been suggested in several studies on the use of ethanol as fuel for transportation.

This study focuses on measurement results obtained in Oslo as part of the project BieBus; "Bio-ethanol in public transport: an integrated approach to evaluate the impact of climate change policies in urban areas". Since 2008, 21 buses running on E95 (bioethanol blended with 5% gasoline) have been operated in one of the most frequent city bus lines (Figure 1). The strong smell of acetic acid has been noted as a negative side effect. The main compounds of interest were acetic acid, formic acid, acetaldehyde and formaldehyde.

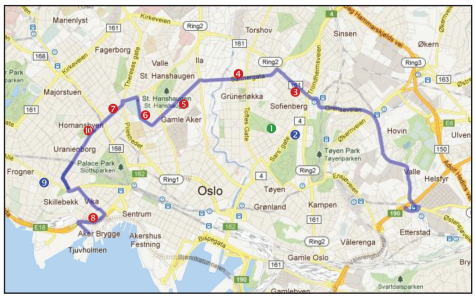

Figure 1: Course of bio-ethanol-fuelled bus line. Sampling locations at traffic sites exposed to bio-ethanol buses (UT E, ●), traffic sites not exposed to bio-ethanol buses (UT nE, ●) and background sites (UB, ●), see Table 1.

Methodology

Following types of measurements have been performed in Oslo:

(1) Ambient roadside concentration of O_3, NO_2, acetic and formic acid was measured in spring and autumn 2011 with passive diffusion gas samplers in 3 different environments; Figure 1.

Table 1. Locations used for passive and active sampling; site category (see Figure 1) and selection of sites for experiments (1) and (2) are indicated (OA: organic acids).

Location	Site	Site Category	NO_2, O_3, OA (passive)	Aldehydes (active)
#1	Sofienbergparken	UB	X	X
#2	Sars' gate	UT nE	X	
#3	C. B. Plass (Ring 2)	UT E	X	X
#4	Sannergata	UT E	X	X
#5	Waldemar Thranes gate	UT E	X	X
#6	Sofies gate (Bislett)	UT E	X	
#7	Josefines gate	UT E	X	
#8	Munkedamsveien	UT E	X	
#9	Bygdøy Allé	UT nE	X	X
#10	Camilla Colletts vei	UT E	X	X

(2) Ambient formaldehyde and acetaldehyde was sampled actively with DNPH cartridges followed by HPLC analysis (Table 1, Figure 1).

Figure 2a: Passive sampling at 10 locations.

Figure 2b: Active aldehyde sampling at 6 locations.

Results and discussion

The main emphasis was on determining possible differences between locations directly exposed to bio-ethanol fuelled buses and locations not exposed.

1) Ambient NO_2, O_3 and organic acids concentrations

The average concentrations of NO_2, O_3, acetic and formic acid are shown in Figure 3. The NO_2 concentration was slightly higher in autumn than in spring and seems to correlate with traffic density (see Table 1). O_3 shows the opposite pattern.

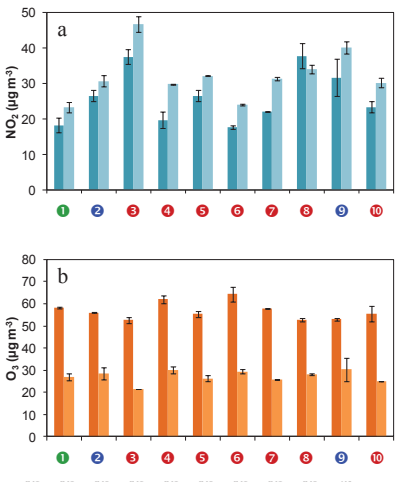

Figure 3 a,b: Average concentrations and standard deviations of NO_2 and O_3 from passive sampling. Left-hand bars at each location: spring campaign, right-hand bars: autumn campaign.

Higher average acetic acid concentration was measured in autumn than in spring (Figure 3). For formic acid no such variation was observed. The results from the spring campaign seem to show slightly lower concentrations in those locations not exposed to bio-ethanol buses. Uncertainties in the interpretation of the results arise from the high water-solubility of acetic acid, other sources and by averaging the concentrations over a long time period.

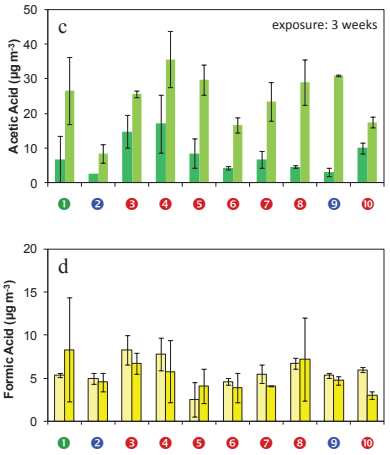

Figure 3 c, d: As Figure 3 a,b. showing acetic and formic acid.

2) Aldehydes concentrations in ambient air

The acetaldehyde concentration seems to be associated with the exposure to bio-ethanol buses, showing lowest levels at the two locations not exposed to bio-ethanol buses (Figure 4). An association between formaldehyde concentration and the exposure to bio-ethanol buses is not observed. This may be explained by the existence of (photo)-chemical processes, such as the production of formic acid by oxidation of formaldehyde. The low F/A ratios (0.16-0.26) observed at locations 5, 10 and 3, which are exposed to emissions from bio-ethanol buses, suggest a high importance of direct emissions.

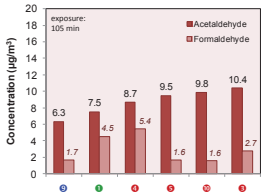

Figure 4: Acetaldehyde and formaldehyde concentrations from active sampling.

Conclusion

- acetaldehyde and acetic acid may be a concern, but additional research is needed.
- higher acetaldehyde concentrations at locations exposed to emissions of bio-ethanol buses; but no large differences between locations directly exposed and not exposed.
- spatial differences of acetic acid concentration; but levels were very low, even below odour threshold values; this is possibly a consequence of measurement type employed, involving low time resolution.
- additional research is needed as both acetaldehyde and acetic acid are known to be compounds harmful to human health and material degradation, and as the use of bio-ethanol as alternative to fossil fuels in transportation is increasing worldwide and uncertainties exist about its impact on urban air quality.

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