Evaluation of atmospheric benzene concentrations in the Helsinki Metropolitan Area in 2000 - 2003

Hellén H., Kukkonen J., Kauhaniemi M., Hakola H., Laurila T. and Pietarila H.

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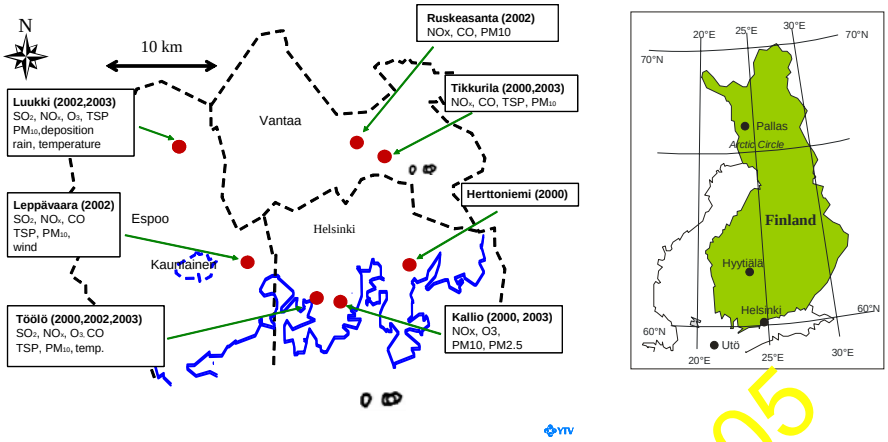
Introduction

- Benzene is a carcinogenic aromatic hydrocarbon
- European Union has set limit values, and upper and lower assessment thresholds for the atmospheric concentrations of benzene (in 2002). An objective of this study was to satisfy the requirements of this EU directive.
- Bz studies in 2000's in Europe are very scarse

Hellén, H., J. Kukkonen J, M. Kauhaniemi M, H. Hakola H, T. Laurila T and H. Pietarila H., 2005. Evaluation of atmospheric benzene concentrations in the Helsinki metropolitan area in 2000-2003 using diffusive sampling and atmospheric dispersion modelling. Atmos. Environ., 39 (2005) 4003–4014.



The measuring stations for benzene in the Helsinki Metropolitan Area (left panel) and regionally (right panel).

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Sampling and analysis methods

- Air samples were collected using both diffusive and pumped adsorbent sampling
- Analysis using thermal desorption unit and a gas chromatograph

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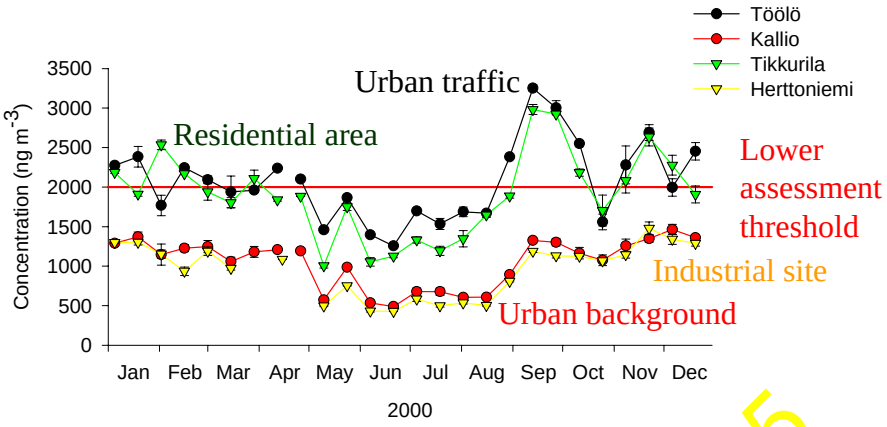

Measured seasonal variation of two-weekly concentrations of benzene at various stations in 2000. The error bars show the standard deviations of simultaneously-measured triplicate samples.

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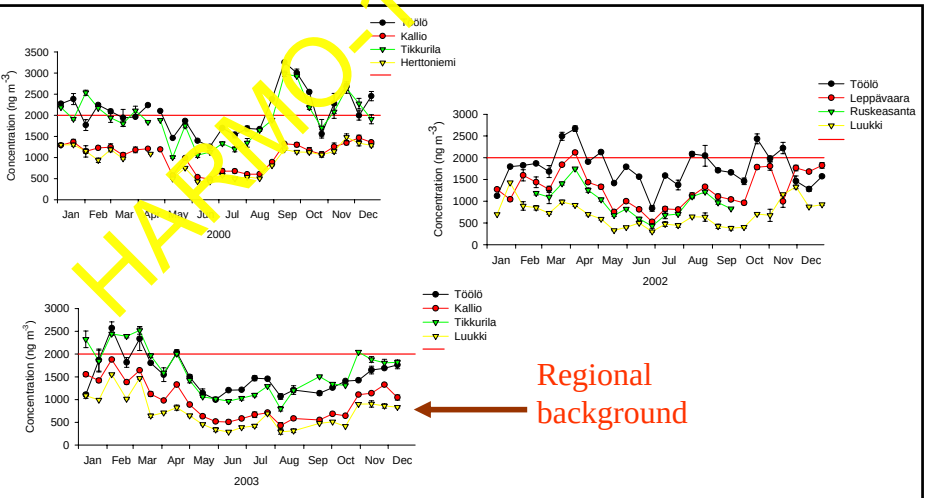

Measured seasonal variation of two-weekly concentrations of benzene at various stations in 2000, 2002 and 2003.

The regional BG is nearly a half of the urban and suburban concentrations.

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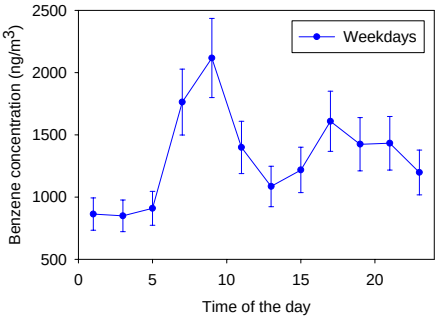

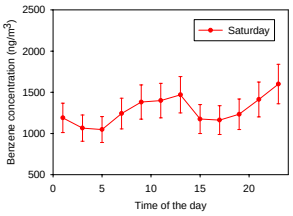

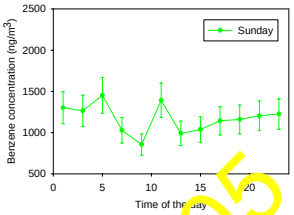

Measured diurnal variation of the benzene concentrations at the urban background station of Kallio in 2001, during weekdays, Saturdays and Sundays. Error bars = experimental uncertainty.

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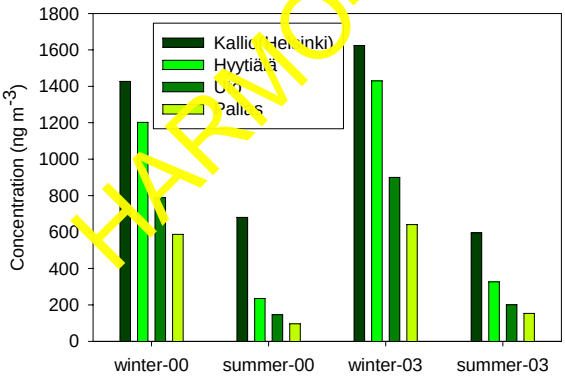

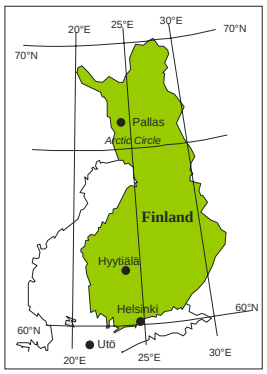

Comparison of the measured benzene concentrations at the urban background station of Kallio in Helsinki with those at the rural and remote sites in the winter and summer of 2000 and 2003.

In summer, the lifetime of benzene in the atmosphere is substantially shorter; it is therefore not transported as far from the main emission sources.

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Benzene emissions from vehicular traffic

- Benzene emissions originating from vehicular traffic depend on a number of factors, such as vehicle type, fuel, travel velocity and cold starts.
- Benzene emissions were evaluated based on the measured total hydrocarbon (THC) emissions and the estimated fraction of benzene in the THC emissions.
  - ✓ The fraction of benzene in THC emissions was estimated mainly based on the hydrocarbon emission measurements by Hellén et al. (2003). The fraction of benzene in THC emissions is 4.0 % for petrol vehicles and 3.0 % for diesel vehicles.
  - ✓ We utilized the THC emission factors based on the COST 319 action, and the MEET project.

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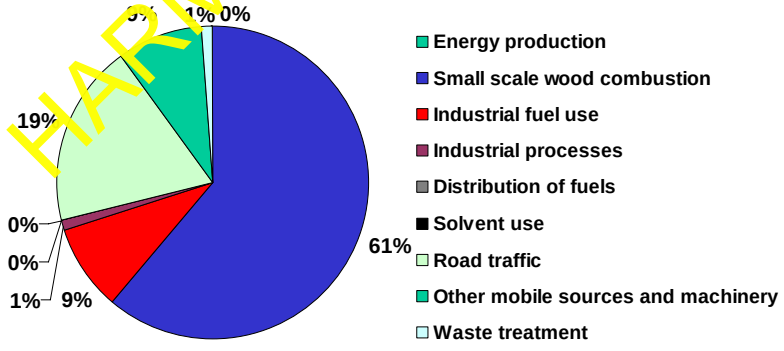
The emissions of benzene in Finland in 2000



In urban areas, the contribution of road traffic to benzene emissions is substantially higher than the nationally-averaged values.

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Dispersion model: CAR-FMI

- Contaminants in the Air from a Road - Finnish Meteorological Institute
- Model includes an emission model, a dispersion model and statistical analysis of the computed time series of concentrations.
- Model utilises the meteorological input data evaluated with the meteorological pre-processing model MPF-FMI.
- The dispersion equation is based on a semi-analytic solution of the Gaussian diffusion equation for a finite line source

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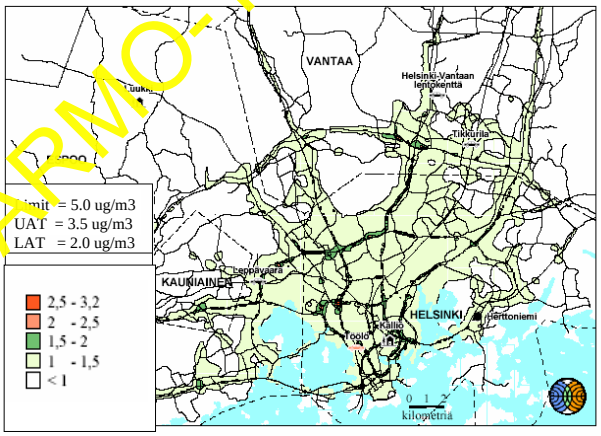

Predicted spatial distribution of the yearly means of benzene concentrations (µg/m³) in the Helsinki Metropolitan Area in 2000.

The legend shows the absolute values of the pollutant concentrations. Limit = EU limit value, UAT = upper assessment threshold, LAT = lower assessment threshold.

The emissions and dispersion were modelled separately for about 6200 road segments.

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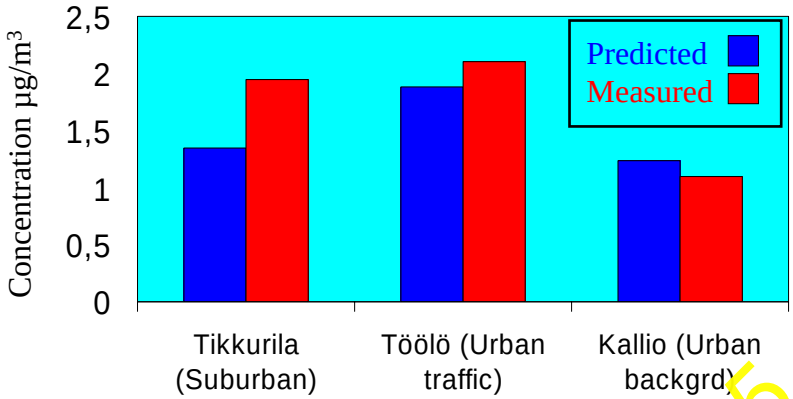

Comparison of the predicted yearly mean benzene concentrations with those measured at three urban monitoring stations in 2000. Predicted values include only vehicular traffic.

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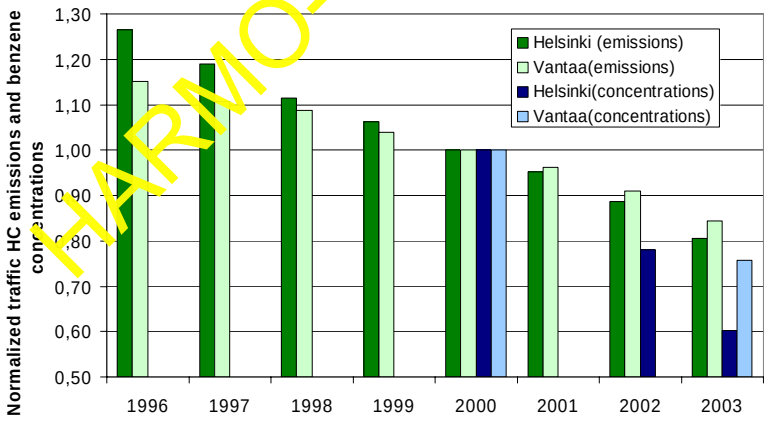

Traffic hydrocarbon (HC) emissions in the cities of Helsinki and Vantaa in 1996-2003, and the differences between the measured ambient benzene concentrations at the stations of Töölö and Tikkurila and the regional background in 2000, 2002 and 2003; both of these are normalized to the values in 2000.

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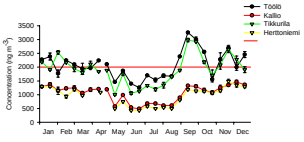
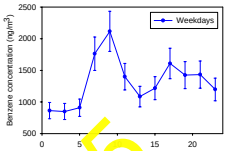
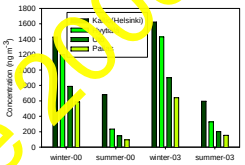
Conclusions - measurements

- The two-weekly values at all stations were below the upper assessment threshold; but exceeded the lower threshold at three stations.
- The concentrations at urban and suburban stations were on the average slightly more than two times higher, compared with those at the regional background station. This indicates that the long-range transported contribution is almost a half.
- The diurnal variation in the benzene concentrations correlates closely with the corresponding temporal variation of traffic flows; the influence of local traffic therefore is therefore crucial.







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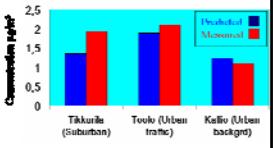
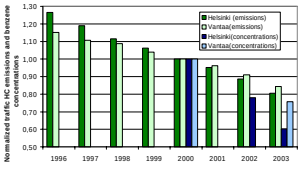
Conclusions – computations

- At all the stations, the predicted yearly averaged concentrations agreed fairly well with the measured data. A slight average underprediction was expected, due to evaporative and wood-burning emissions (those were not included in computations).



Conclusions – source contributions

- We conclude that the most important emission source category is the exhaust emissions from local vehicular traffic; however, the long-range transported background also has a substantial influence on the measured benzene concentrations.



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FMI has moved to a new building called ”Dynamicum”

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Back-up slides

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Lifetimes of different VOC's (h)

	January	July
Ethane	23146	754
Propane	5173	168
Benzene	4836	158
i-butane	2553	83
n-butane	2342	76
toluene	998	33
ethylbenzene	838	27
2-ethyltoluene	484	16
o-ksylene	252	8
1,2,3-trimethylbenzene	182	6
a-pinene	111	4
carene	68	2
isoprene	59	2

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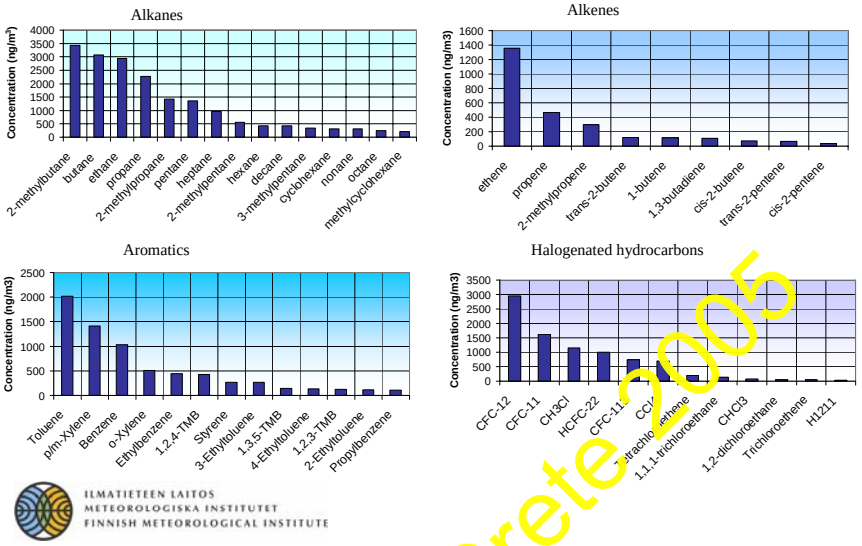
Concentrations of the volatile organic compounds in Helsinki



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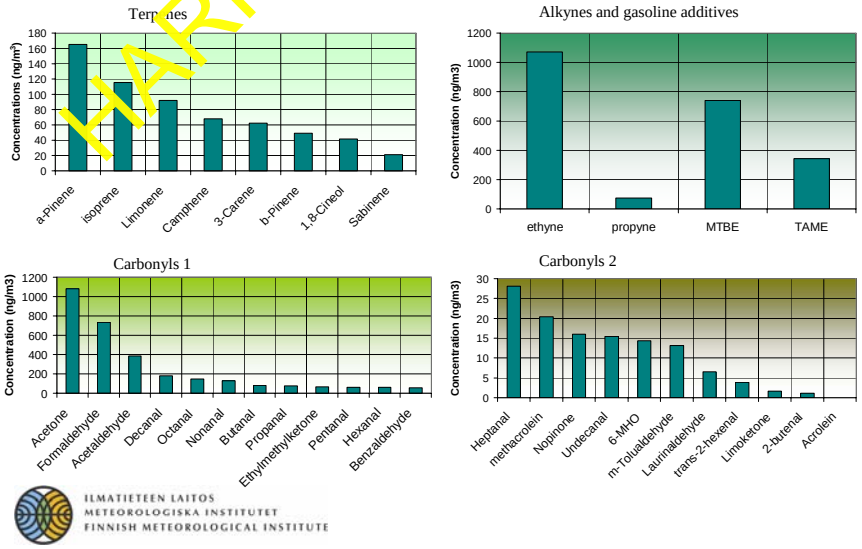

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Sampling methods used in Helsinki

-passive sampling (aromatic hydrocarbons)

-pumped adsorbent sampling (C_6-C_{10} hydrocarbons)

-online sampling (C_6-C_{10} hydrocarbons)

-passive canister sampling (light C_2-C_6 hydrocarbons and halogenated hydrocarbons)

-DNPH-sampling (aldehydes and ketones)

Analysed using a gas-chromatograph with mass-spectrometer, flame ionization detector or electron capture detector.
(DNPH-samples with LC-MS)

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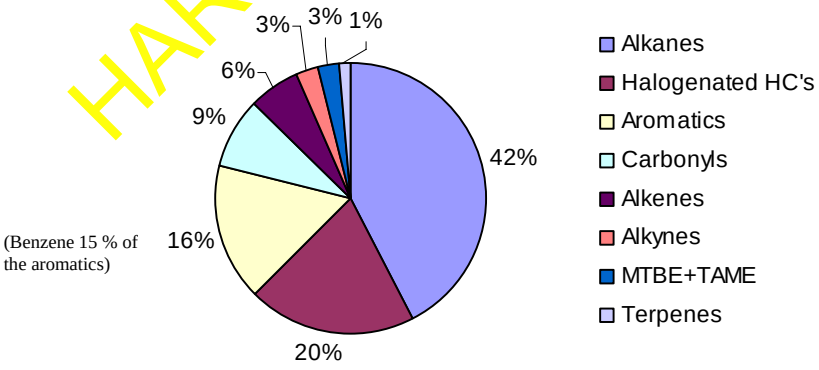
Contributions of different compound groups in Helsinki



(Benzene 15 % of the aromatics)

Total concentration 43000 ng/m^3

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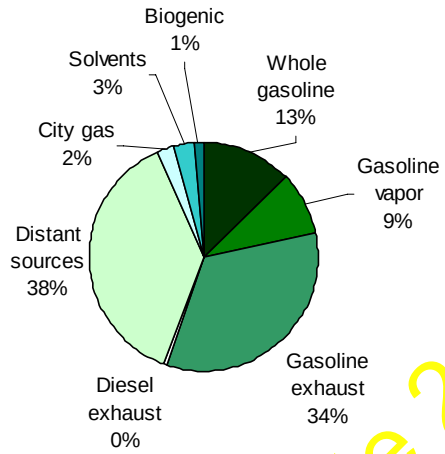
Sources of the hydrocarbons in Helsinki based on the chemical mass balance study



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