Characterizing urban traffic emissions across Europe: Insights from canister sampling in Net4Cities

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Motivation

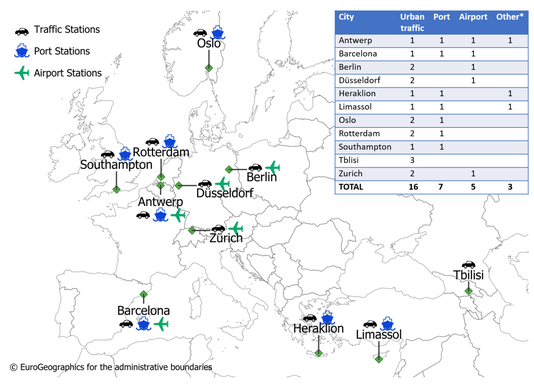
Three integrated pillars of Net4cities

Measure
Real-time air quality and noise measurement

Attribute
Apportionment of exhaust and non-exhaust emission sources

Act
Co-created policy with stakeholders

- Focus on emerging pollutants, such as volatile organic compounds (VOCs), ultrafine particles (UFPs), and ammonia (NH_3), to advance understanding of urban emissions.
- Contributing to the implementation of the EU's Zero Pollution Action Plan and the new EU Air Quality Directive (EU/2024/2281).

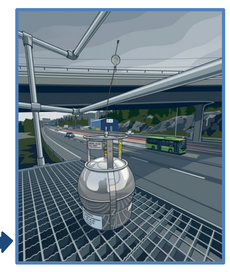


City	Urban traffic	Port	Airport	Other*
Antwerp	1	1	1	1
Barcelona	1	1	1	
Berlin	2		1	
Düsseldorf	2		1	
Heraklion	1	1		1
Limassol	1	1		1
Oslo	2	1		
Rotterdam	2	1		
Southampton	1	1		
Tbilisi	3			
Zurich	2		1	
TOTAL	16	7	5	3

Fig. 1. Map of 11 partner cities and measurement locations

Method

Sampling Period: Once a month, the first Wednesday (08:00 to 09:00 LT) from March 2025 to April 2026

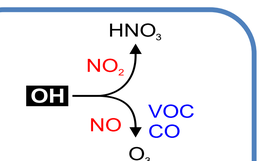


Canister sample

GC analysis

Quantitative analysis of NMVOCs, and trace gases

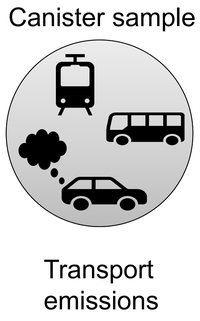
OH-reactivity measurement



$$R_{VOC} = \sum k_{OH+VOC_i} \times [VOC_i]$$

$$R_{NO_2} = k_{OH+NO_2} \times [NO_2]$$

Product of VOC concentrations and their respective reaction rate constants with OH.



Transport emissions

Working principle of GC

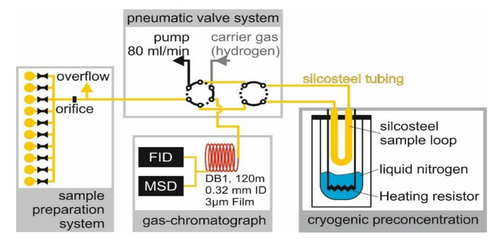


Fig. 2. Schematic representation of the analytical workflow.

VOCs from canister measurement

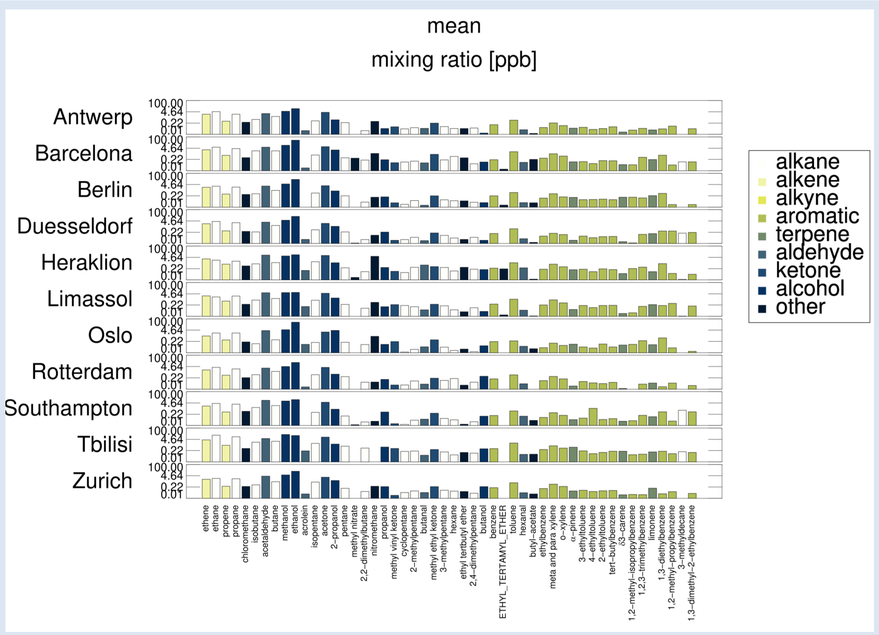


Fig. 3. Variability in VOC mixing ratios across cities (log-scale)

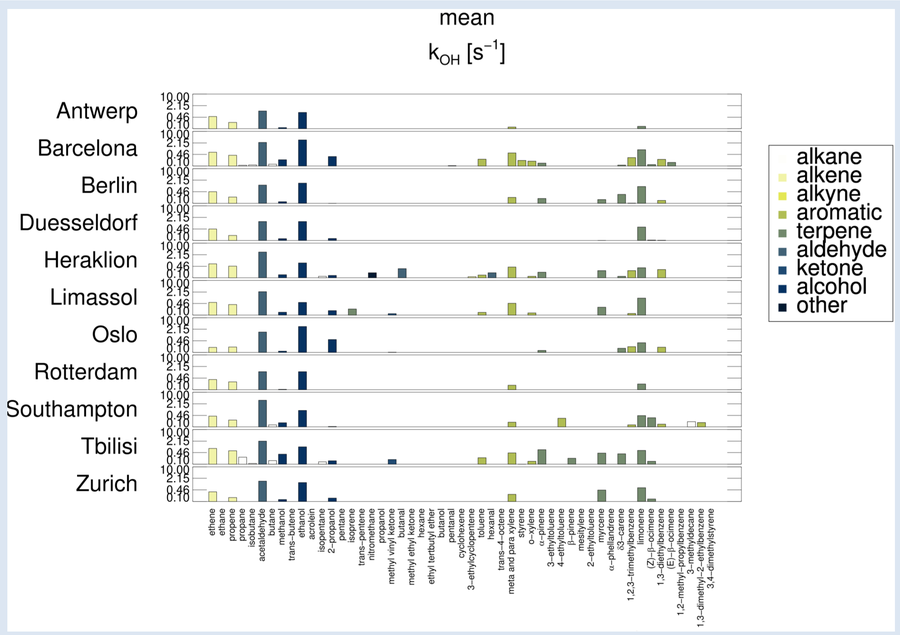
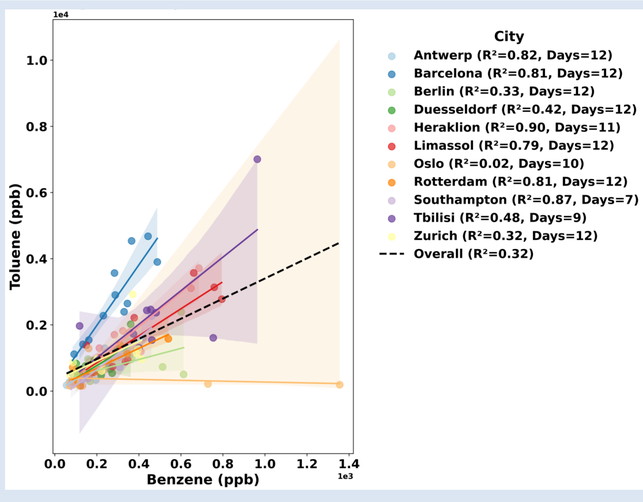


Fig. 4. Variation in OH-reactivity (k_{OH}) across cities (log-scale)



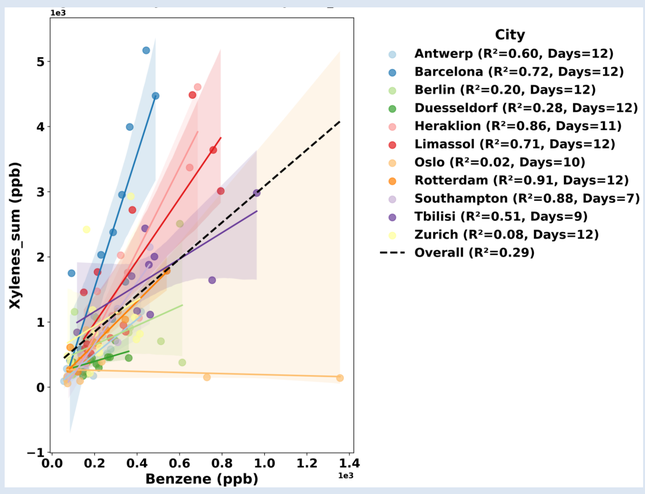
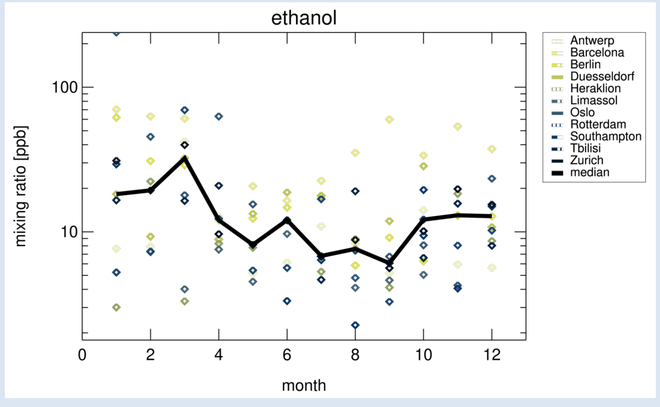


Fig. 6. Linear regression analysis of aromatic VOCs across the Net4Cities network: Benzene vs. Toluene (top) and Benzene vs. Xylenes (bottom).

- Oxygenated VOCs (OVOCs) like methanol, ethanol, acetaldehyde, and acetone dominate the total mixing ratios across all cities.
- Although terpenes and aromatics contribute only a small fraction to the total VOC mixing ratio, they contribute significantly to OH reactivity driving local ozone production and secondary organic aerosol (SOA) formation.



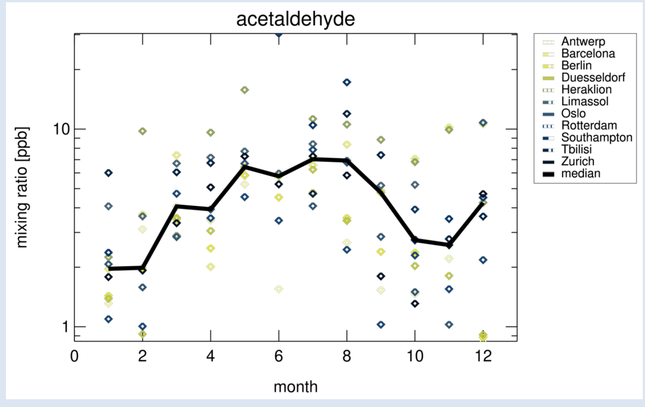


Fig. 5. Contrasting seasonal variation of ethanol and acetaldehyde (month 1: March 2025 and month 12: February 2026)

Ethanol shows strong winter maxima which can be associated with windshield washer fluids & low mixing layer height, while acetaldehyde, show summer maxima, which can be driven by urban biogenic emission and secondary chemistry.

Strong inter-species regression among BTEX group suggests co-emission from a common fresh traffic emission source.

Trace gases from canister measurement

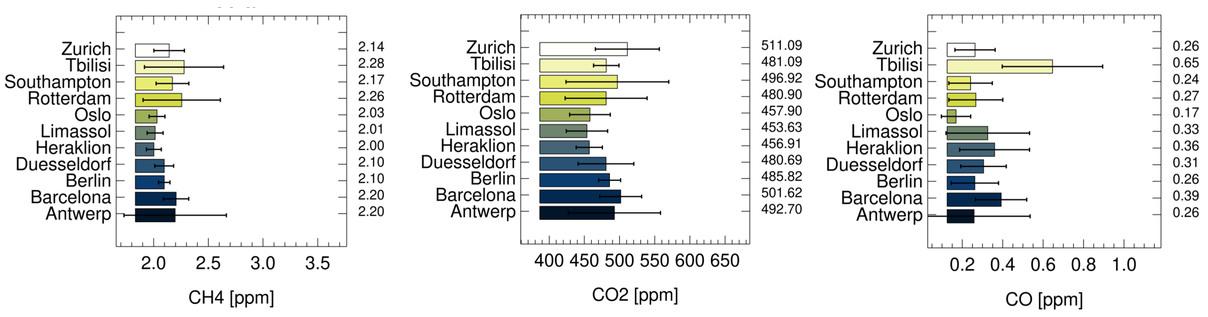


Fig. 7. Variation in methane (CH_4), carbon dioxide (CO_2) and carbon monoxide (CO) concentrations across cities.

- CH_4 highest petrochemical-dominated port cities (Antwerp, Rotterdam).
- CO_2 was highest in Zurich and lowest in Limassol.
- High CO concentration was observed in Tbilisi, which was more than three times than of Oslo.

Summary and conclusions

- Ethanol peaks in winter (windshield washer fluid), whereas Acetaldehyde peaks in summer (photochemistry/biogenic).
- OVOCs dominate total mixing ratios, but aromatics and terpenes are significant contributors to OH-reactivity driving ozone and SOA formation.
- Strong BTEX regressions confirm a consistent, fresh traffic emission in most of the cities.
- Trace gas differences were also notable: CH_4 was highest in Antwerp and Rotterdam, CO_2 in Zurich, and CO in Tbilisi.

Acknowledgement

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