On-road emission characteristics of VOCs from vehicles in Beijing, China

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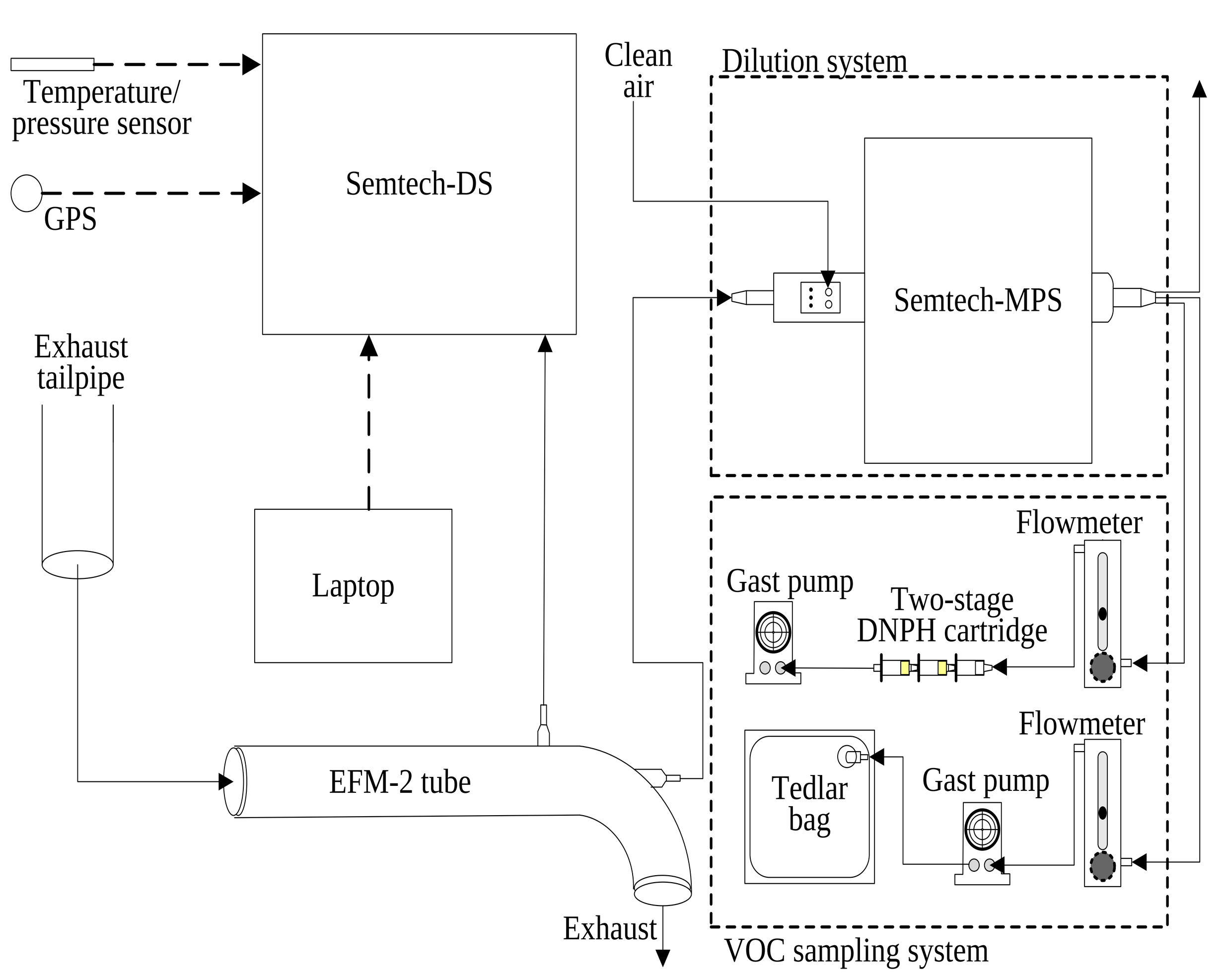
Introduction

- VOCs are well known as important ozone that contribute to the formation of photochemical smog and secondary organic aerosols, which can pose a hazard to human health and cause direct damage .
- With economic development that has led to increased numbers of vehicles, automotive exhaust has become the main source of VOCs in urban areas.
- In the last decade, many studies have focused on the emission characteristics of VOC species from vehicles using the chassis dynamometer, which may not reflect the real emission situation.
- This work aimed at characterizing the VOC emissions of vehicles in the real world of Beijing. 30 light-duty gasoline vehicles (LDGV) and 18 diesel trucks (DTs) were evaluated using a portable emission measurement system (PEMS) as they drove on predesigned, fixed test routes.

Experimental section



VOC sampling sysytem

- The tested vehicles were driven on a predesigned fixed route following road traffic. Bothe the test routes for LDGVs and DTs included highways and non-highway roads to reflect the impact of driving cycles on VOCs.
- In total, 30 LDGVs with different emission standards and 18 China III DTs with different sizes were tested.
- Alkanes, alkenes, aromatics, halohydrocarbons species sampled through Teldar bag were analyzed by GC/MS; carbonyls were quantified using the external standard method with HPLC.

Results

VOC composition

LDGVs top 20

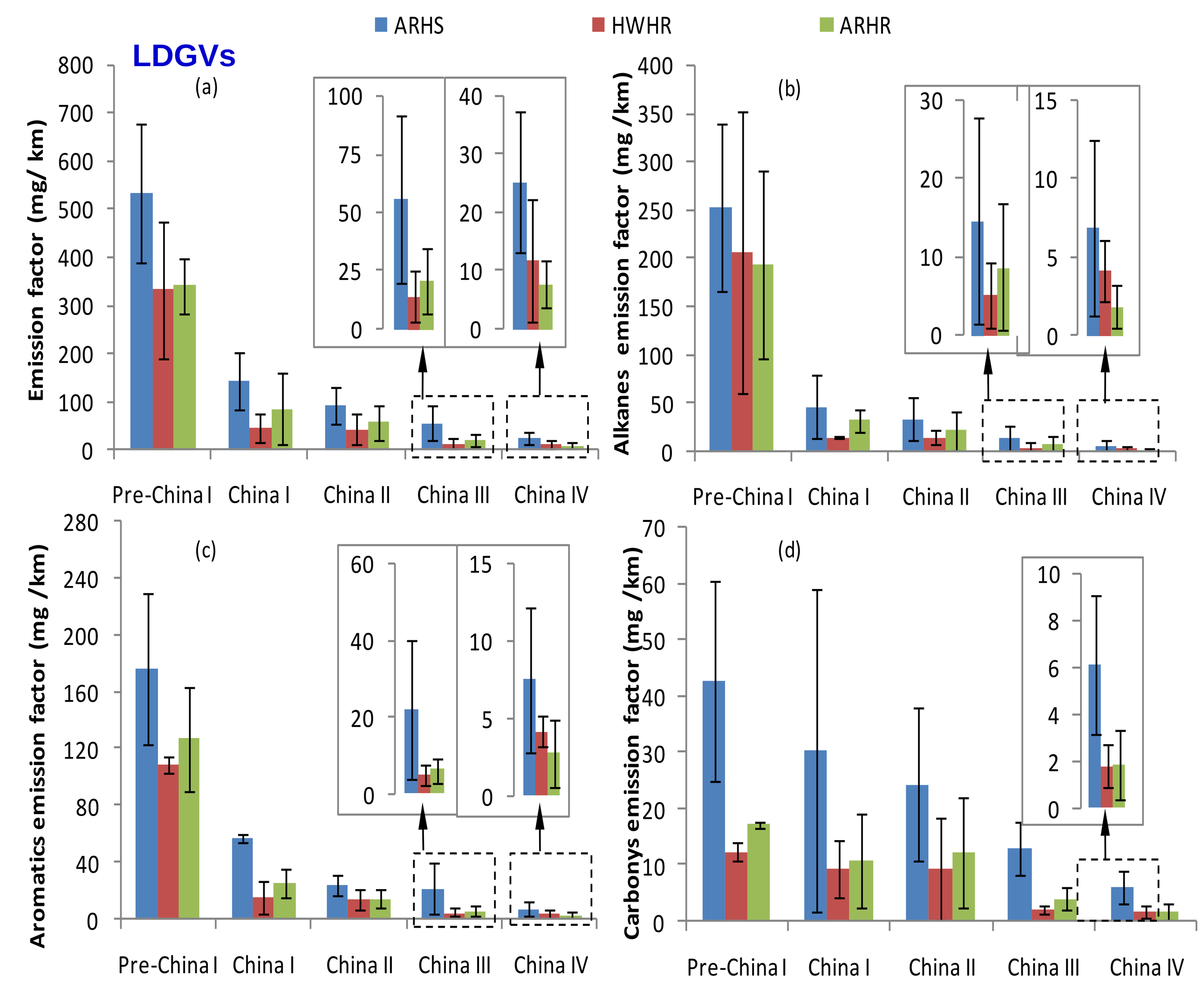
Compounds	Percentages (%)	Compounds	Percentages (%)
Toluene	11.2	Hexane	2.9
i-Pentane	6.1	Heptane	2.7
Benzene	5.9	Acrolein	2.5
Formaldehyde	5.5	1,2,3-Trimethylbenzene	2.4
Methylene chloride	4.6	Methyl tert-butyl ether	2.4
m-and p-Xylene	4.1	2-Methylhexane	2.0
Pentane	3.7	Methylcyclopentane	2.0
3-Methylpentane	3.6	Propylene	1.9
2-Methylpentane	3.6	Ethane	1.8
Acetaldehyde	3.2	Total	66.1
Ethylbenzene	3.2		

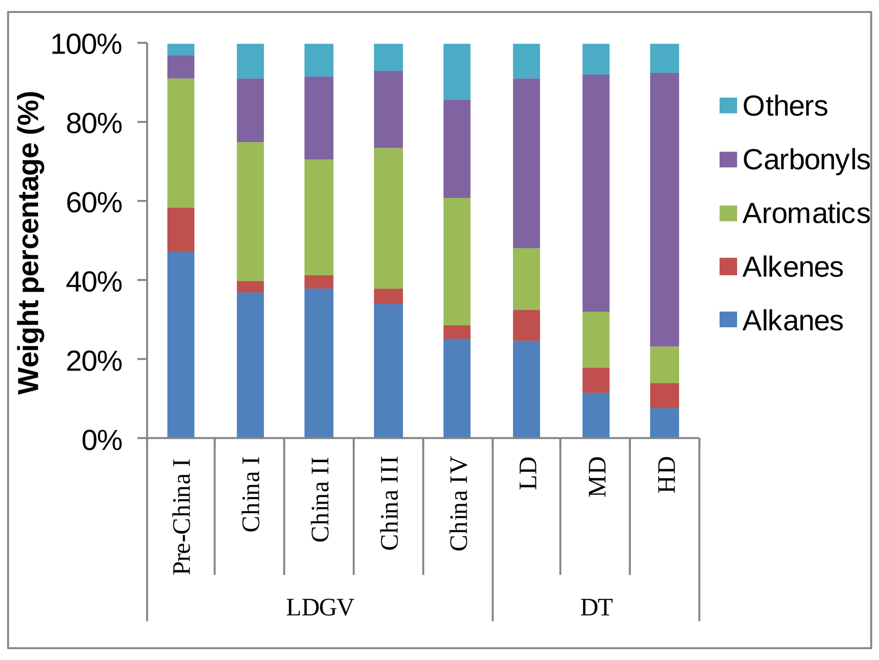
DTs top 20

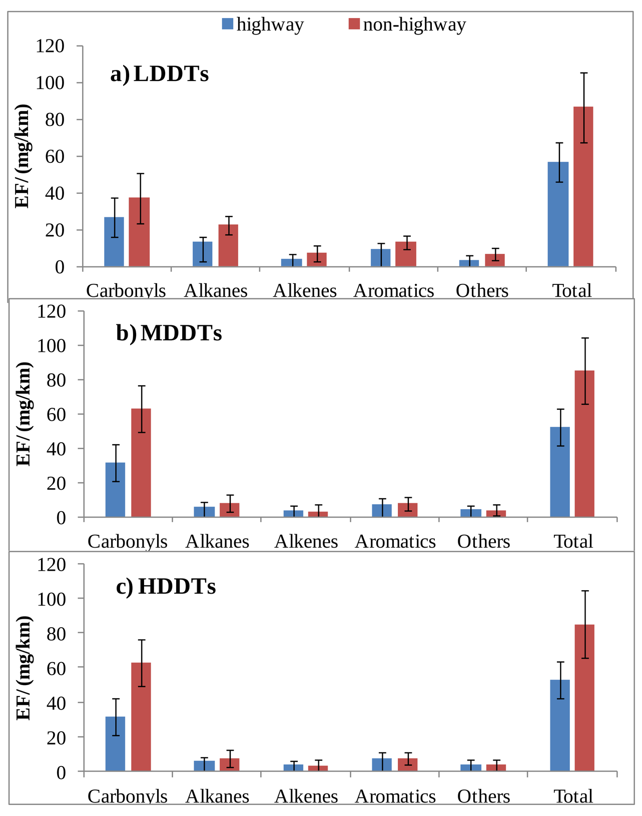
Compounds	Percentages (%)	Compounds	Percentages (%)
Formaldehyde	29.9	Acetone	2.1
Acetaldehyde	11.7	Propene	2.1
Ethylene	4.4	2-Methylpentane	1.6
Ethyne	4.3	m,p-Xylene	1.5
Propionaldehyde	3.8	Butyraldehyde	1.5
Iso-pentane	3.5	1,3-Dimethyl benzene	1.5
Toluene	3.3	Methyl tert-butyl ether	1.5
Acrolein	2.6	1,2,3-Trimethyl benzene	1.4
Crotonaldehyde	2.4	Decane	1.3
Pentane	2.2	Total	85.1
Benzene	2.2		

- 74 VOC species were quantified for LDGVs, and 64 for DTs.

Impact of vehicle types and driving patterns







- The average VOC emission factors of Pre-China I, China I, China II, China III and China IV vehicles were 469.3 $\pm$ 200.1, 80.7 $\pm$ 46.1, 56.8 $\pm$ 37.4, 25.6 $\pm$ 11.7 and 14.9 $\pm$ 8.2 mg/km, respectively, illustrating that VOC emissions decreased significantly under stricter vehicular emission standards.
- DTs emitted more carbonyls compared with gasoline vehicles. Carbonyls accounted for 42.7%-69.2% of the total VOCs in the three types of tested diesel trucks
- Driving patterns also influenced the VOC emissions from tested vehicles. The average VOC emission factors for tested vehicles under urban driving patterns were higher compared to those under highway driving patterns.

Acknowledgments

This study was supported by projects of the National Natural Science Foundation of China (41275124, 41005068).

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