Indoor-Outdoor Volatile Organic Compounds (VOCs) Levels in Urban and Industrial Area of Dhaka City, Bangladesh

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Volatile Organic Compounds (VOCs)

EU

- Organic compounds
- Vapor pressure greater than 10 Pa at 20°C

VOCs impact on human health and global environment

- Health effects
  - Indoors
  - Outdoors

- Environmental effects
  - Stratospheric ozone depletion
  - Tropospheric ozone formation
  - Global warming

http://oecotextiles.wordpress.com
Objectives

Main Objective:
To investigate the presence and ambient concentration levels of VOCs in both indoor and outdoor environment in urban and industrial areas of Dhaka city, Bangladesh.

Specific objectives:
- **Comparison** on the indoor and outdoor VOCs in the urban and industrial area of Dhaka city:
  - TVOCs, individual group and subgroup of TVOCs, BTEX and benzene levels
- Indoor-to-outdoor ratio (I/O)
- Source identification » diagnostic ratios and correlation of coefficients
- Estimation of ozone formation potential of the measured VOCs
- **Comparison** with other countries studies
Materials and Methods
Sampling plan

Two Sampling Campaigns in Dhaka

Urban area (Mirpur)
1. House (indoor)
2. Roadside (outdoor)
3. Park (outdoor)

Industrial area (Tejgaon)
1. House (indoor)
2. Roadside (outdoor)
3. Industrial ambient (outdoor)

3 sites/area

- 3 days sampling/site (1 weekend and 2 weekdays)
- 2 times sampling/day - Morning and afternoon at rush hour
- 6 sampling sites with 6 samples/site
- In total 36 samples and 3 blanks
- Roadside sample: heavy traffic
Materials and Methods

1. Active sampling: portable pump (Gilair)
2. Sorbent: Tenax TA Tube
3. Internal Standard: Tol-d_8
4. Analysis: TD-GC-MS analysis
5. Quantification

\[ C_a = \frac{m_a}{Q \times t} = \frac{m_a}{V} \]

- \( V \): volume of sampled air
- \( Q \): flow rate of sampling pump = 93mL/min
- \( t \): sampling time = 30min
- \( C_a \): concentration of analyte
Results and Discussion
Total Volatile Organic Compounds (TVOCs)

Boxplot based on 6 samples/site
TVOCs: ∑ 39 of VOCs

Highest maximum value
Industrial street around 151 µg/m³ (N=36)

Highest variance

Lowest minimum value urban park around 14 µg/m³ (N=36)

Sampling sites
Results and Discussion
Total Volatile Organic Compounds (TVOCs) Groups

- Total Volatile Organic Compounds (TVOCs) (Σ39 VOCs)
  - Total (Cyclo-)alkanes (Σ10 VOCs)
  - Total Terpenes (Σ3 VOCs)
  - Total Aromatic compounds (Σ14 VOCs)
  - Total Halogenated compounds (Σ4 VOCs)
  - Total Oxygenated compounds (Σ8 VOCs)
Total Aromatic compounds are the major contributors (42-61%).

Total Oxygenated compounds are 2nd major contributors in park 38%; Six site range (10-38%).

Total Halogenated compounds <1% & Total Terpenes (1-2%).

Total (Cyclo)-Alkanes (17-28%).
Mean of Total Benzene-Toluene-Ethylbenzene-Xylene (∑BTEX)

Highest ∑BTEX: Industrial Street (mean: 47 µg/m³)

Benzene: (mean 3-12 µg/m³)

Highest Toluene: (mean 5-22 µg/m³)

Lowest ∑BTEX: urban park (mean: 10 µg/m³)
Country level comparison for BTEX in urban area
Benzene-Toluene-Ethylbenzene-Xylene (ΣBTEX)

Highest ΣBTEX: Hanoi, Vietnam (mean: 97 µg/m³)

Lowest: Ghent, Belgium (mean: 12 µg/m³)

Mean ΣBTEX concentration (µg/m³) level
mean ΣBTEX concentration of Dhaka, BD
  » 5 times lower than Hanoi, VT
  » same as Manila, PH
  » 1.5 times higher compare to Mekelle, ET
  and Ghent, BE
Country level comparison of mean Benzene concentration

Highest indoor benzene: Hanoi, Vietnam (mean: 8 µg/m³)
Lowest: Manila, Philippines (PH) (mean: 1.24 µg/m³)

Flemish indoor quality guideline for benzene, 2007: 2 µg/m³
Country level comparison of mean Benzene concentration

EU Directive/2008/50: ambient air guideline for benzene: 5 µg/m³ (year average)

Highest outdoor benzene urban streets of Hanoi, Vietnam (VT) (mean: 32 µg/m³)
Conclusions and Recommendation

- This study provide information on a spectrum of 39 VOCs concentration levels;
- The differences in concentration profile of VOCs at urban and industrial area in Dhaka were interpreted by TVOCs, BTEX and benzene values;
- The benzene concentration level was higher than the guidance value (indoor: 2µg/m³ and outdoor: 5µg/m³) except urban park;
- Aromatic compounds were the major contributors (42-61%) and Halogenated compounds were minor contributors(<1%);
- Among the countries, the highest ∑BTEX (mean: 97µg/m³) was measured in Hanoi, Vietnam and the lowest indoor benzene measured in the Manila, Philippines (mean:1.24µg/m³);
- Further studies concerning more sites and seasonal variations are recommended.
Thank You
### Sample Preparation
- Conditioning of Tenax TA tubes
- Preparation of closed two-phase system (CTS)
- Loading with internal standard (Tol-d₈)

### Sampling
- Sampling Campaign in Dhaka City (30/08 2013 to 11/09/2013)
- Active sampling - portable pump (Gilair)

### 1st Standard Calibration
- TD-GC-MS Standard calibration

### Separation & Detection
- TD-GC-MS Analysis
- Full scan mode masses from m/z 29 to 300

### Identification
- Chromatogram, mass spectrum,
- Total ion current (TIC),
- Selective ion monitoring (SIM) mode,
- Standard Calibration, Library using X-calibur

### 2nd Standard Calibration
- TD-GC-MS Standard calibration
- RSRF : Relative sample response factor

### Quantification & Data Interpretation
- Excel & S-plus (Spotfire S+ 8.2)
Materials and Methods (Extra)
Quantification

\[
\text{RSRF} = \frac{\text{SRF}_a}{\text{SRF}_{st}}
\]

\[
\text{RSRF}_{L,L} \approx \text{RSRF}_{G,G}
\]

\[
= \left( \frac{A_a}{A_{st}} \right) \times \left( \frac{m_{st}}{m_a} \right)
\]

\[
m_a = \frac{A_a \times m_{st}}{\text{RSRF}_{L,L} \times A_{st}}
\]

\[
C_a = \frac{m_a}{Q \times t} = \frac{m_a}{V}
\]

RSRF\(_{L,L}\) : loaded from liquid phase
RSRF\(_{G,G}\) : loaded from gas phase
\(\text{SRF}_a\) : sample response factor of the analyte
\(\text{SRF}_{st}\) : sample response factor of standard
\(m_a\) : mass of analyte
\(m_{st}\) : mass of internal standard (Tol-d\(_8\))
\(A_a\) : peak area of the analyte
\(A_{st}\) : peak area of the internal standard
\(V\) : volume of sampled air
\(Q\) : flow rate of sampling pump
\(t\) : sampling time
\(C_a\) : concentration of analyte
Sampling sites (Extra)

Urban Sampling

Industrial Sampling