

[P1.98]

Polycyclic aromatic hydrocarbons in residential houses situated in urban area: Indoor versus outdoor concentrations and associated health risks

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As people spent majority of their time indoors, the quality of indoor air is an important parameter influencing human health. A substantial part of indoor pollution may result from outdoors, in urban areas vehicular transport being one of the most health–relevant emission sources. To further understand its negative impact on human health, the objective of this work was to study the influence of traffic emissions on indoor levels of PAHs in non–smoking homes, and to estimate the associated health risks.

The samples were collected in winter 2009 in an urban district of city of Porto, Portugal. During 60 days, 18 PAHs (16 recommended by USEPA as priority pollutants, benzo[*j*]fluoranthene, and dibenzo[*a,l*]pyrene) were sampled in indoor and outdoor air (i.e. both in gas and particulate phases) using constant low–flow samplers and an air flow rate of 38 L/min. Carcinogenic risks associated with exposure to PAHs were assessed according to the methodology provided by US EPA Region III Risk–based Concentration Table.

The mean concentration of 18 PAHs in outdoor air ranged from 16.8 to 148 ng/m³ (mean of 69.9 ng/m³). The results showed that traffic emissions were the major source of outdoor PAHs. The corresponding levels of PAHs indoors ranged from 17.9 and 62.1 ng/m³ with a mean of 34.5 ng/m³. The indoor/outdoor ratios of individual PAHs were lower than 1 indicating the absence of significant indoor PAH emissions sources. The estimated values of carcinogenic risks exceeded the health–based guideline levels, thus demonstrating that long–term (> 65 years) exposure to PAHs at levels found both indoors and outdoors would eventually cause risk of developing cancer.

This work was funded by FCT fellowship number SFRH/BPD/65722/2009.

Keywords: traffic emissions, indoor/outdoor air, PAHs, carcinogenic risks

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Objectives

- To study the influence of traffic emissions on indoor levels of polycyclic aromatic hydrocarbons (PAHs) in non-smoking homes
- To estimate risks associated with exposure to PAHs

Methods

SAMPLING

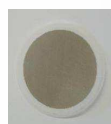
- Outdoors: urban area in Porto, Portugal with predominant traffic influence
- Indoors: non-smoking residences in the same location
- 18 PAHs (16 USEPA priority PAHs, dibenzo[a,l]pyrene, and benzo[j]fluoranthene) simultaneously collected in gas phase and particles (PM₁₀ and PM_{2.5})

- Pre-cleaned polyurethane form (PUF) plugs
- Polytetrafluoroethylene membrane filters

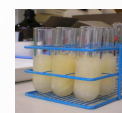
Non-exposed
PUF plugs



Non-exposed
PTFE filters



Exposed PTFE
filter



PUF plugs
extracts

ANALYTICAL METHODS

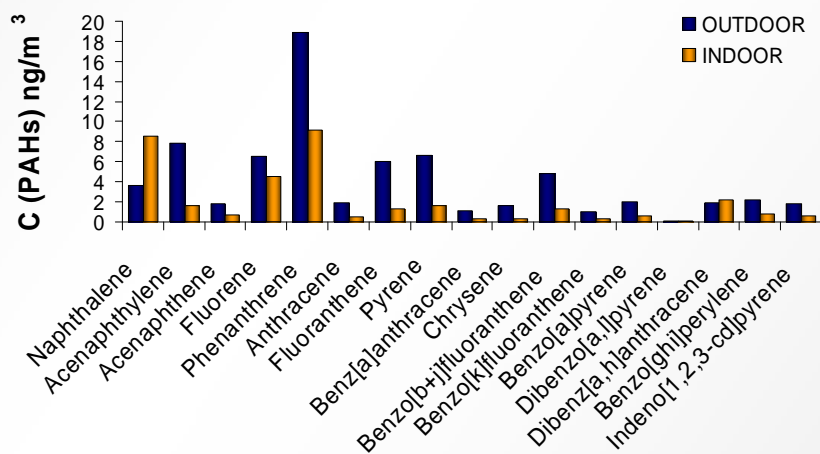
- Microwave assisted extraction
- Liquid chromatography with fluorescence and diode array detectors in series

RISK ANALYSIS

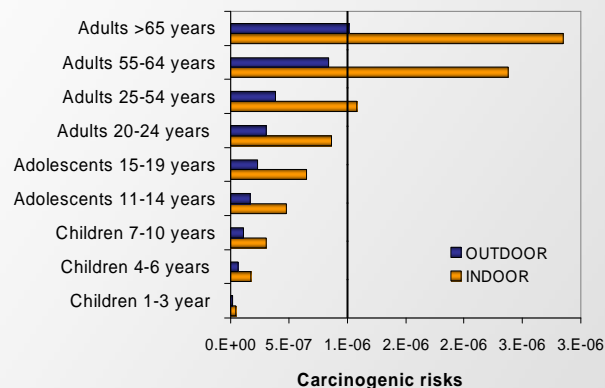
- Methodology provided by US EPA Region III Risk-based Concentration Table
- Nine age categories

Results

Mean outdoor and indoor concentrations of PAHs in air (i.e. sum in particles + gas phase)



Estimated target carcinogenic risks^a of PAHs in air



^aRisks expressed as sum of target carcinogenic risk values of eight individual PAHs: naphthalene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene

Conclusions

- Outdoors, the total concentration of 18 PAHs (Σ PAHs) in air ranged from 16.8 to 148 ng/m³ (mean of 69.9 ng/m³). Indoors, the levels of PAHs were lower, with Σ PAHs ranging from 17.9 and 62.1 ng/m³ (mean of 34.5 ng/m³).
- Outdoors the target carcinogenic risks exceeded the USEPA health-based guideline level (10⁻⁶) for seniors indicating that long-term exposure to PAHs at observed levels increases carcinogenic risks.
- USEPA health-based guideline was exceeded indoors for 3 age categories: adults with 25-54 (1.08x10⁻⁶) and 55-64 years (2.38x10⁻⁶), and for seniors (2.85x10⁻⁶). Despite much lower PAHs concentrations, carcinogenic risks in studied homes were approximately three times higher than outdoors.
- No significant indoor emissions source of PAHs was identified in homes. In agreement, the daily indoor/outdoor ratios of individual PAHs were lower than 1 indicating significant contribution of PAHs from outdoors.
- Outdoor emissions namely from traffic were the major contributor of indoor PAHs.