Polycyclic Aromatic Compounds in Brno Schools and Kindergartens

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Study Goal

Identify polycyclic aromatic compounds (PACs) concentrations in kindergartens and schools in Brno urban and rural areas using active and passive air sampling to understand the seasonal and spatial patterns and inform on the dominant sources of PAC exposure to children.

Introduction

PACs such as polycyclic aromatic hydrocarbons (PAHs) are pollutants of concern for human health due to their mutagenic and carcinogenic properties. Combustion processes such as coal combustion, traffic, industry, incineration, wood burning and activities such as cooking, barbequing, candle burning are the main sources of PAHs in the environment[1]. To evaluate non-dietary human exposure to PAHs, both outdoor and indoor sources must be accounted, especially for high GDP countries where people can spend more than 90% of their time indoors[2]. Humans are primarily exposed to PAHs through ingestion and inhalation. Air inhalation is particularly important with respect to respiratory health effects such as increased risk of lung cancer[3]. It is therefore vital to recognize different PACs in the environment, and identify dominant sources, to inform on measures that will help to decrease their concentrations and reduce human exposure.

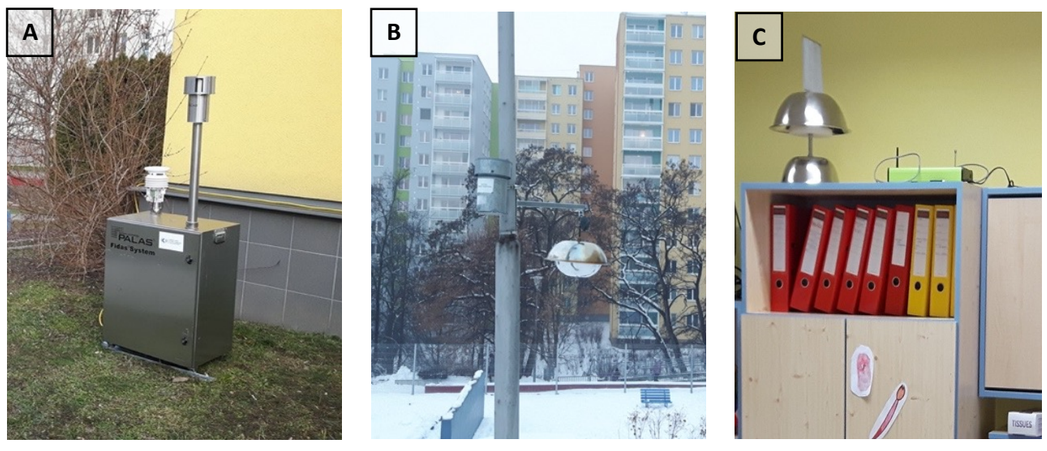

Figure 2: A) active air sampler Palas Fidas 210S, B) passive air sampler with PUF disks, disks are closed for outdoors use, C) passive air sampler with PUF disk, disks are opened for indoors use and GRIMM Mini Laser Aerosol Spectrometer, model 11E

PhD topic – Influence of the built environment on human exposure to chemicals
Study 1 – PACs in Brno Schools and Kindergartens
Study 2 – Chemicals of Concern in Indoor Dusts
Study 3 – Interactions between Chemicals of Concern in Indoor Dusts and Dust Microbiome

Objectives Study 2 & 3
- Characterize chemical pollution and microbiome profiles in indoor settled dust from a large set of homes.
- Examine interactions between biological organisms and specific pollutants in dust.
- Generalize dust profiles according to environmental parameters to identify key factors driving chemical and microbial exposures via dust

Methods Study 2 & 3
- Collection of indoor settled dust from participant's homes with filter equipped vacuum cleaner
- Extraction and clean up of the dust samples and analysis with GC-MS/MS, LC-MS/MS
- Target compounds include flame retardants, plasticizers, pesticides, bisphenols, PCP additives, PFAS

Methods

- Indoor and outdoor air samples were collected in 5 different areas of Brno (Bohunice, Trnitá, Židenice, Líšeň and Jehnice) covering urban, suburban and rural locations. (Fig. 1)
- Passive air samplers with PUF disks were used to collect PACs indoors and outdoors. A double-bowl version was used outdoors (Fig. 2B) and single-bowl version for indoors sampling (Fig. 2C).
- Active air samplers, Palas Fidas 210S (Fig. 2A) and model 11E GRIMM Mini Laser Aerosol Spectrometer were used outdoors and indoors, respectively, to measure ambient particulate matter.
- PUF samples were extracted using Soxhlet extraction with dichloromethane. The extracted samples were cleaned with a silica gel column eluted with dichloromethane. PACs were analyzed using gas chromatography mass spectrometry (GC-MS).

Figure 1: Sampling sites, Bohunice, Trnitá, Židenice, Líšeň and Jehnice, MŠ = kindergarten, ZŠ = primary school

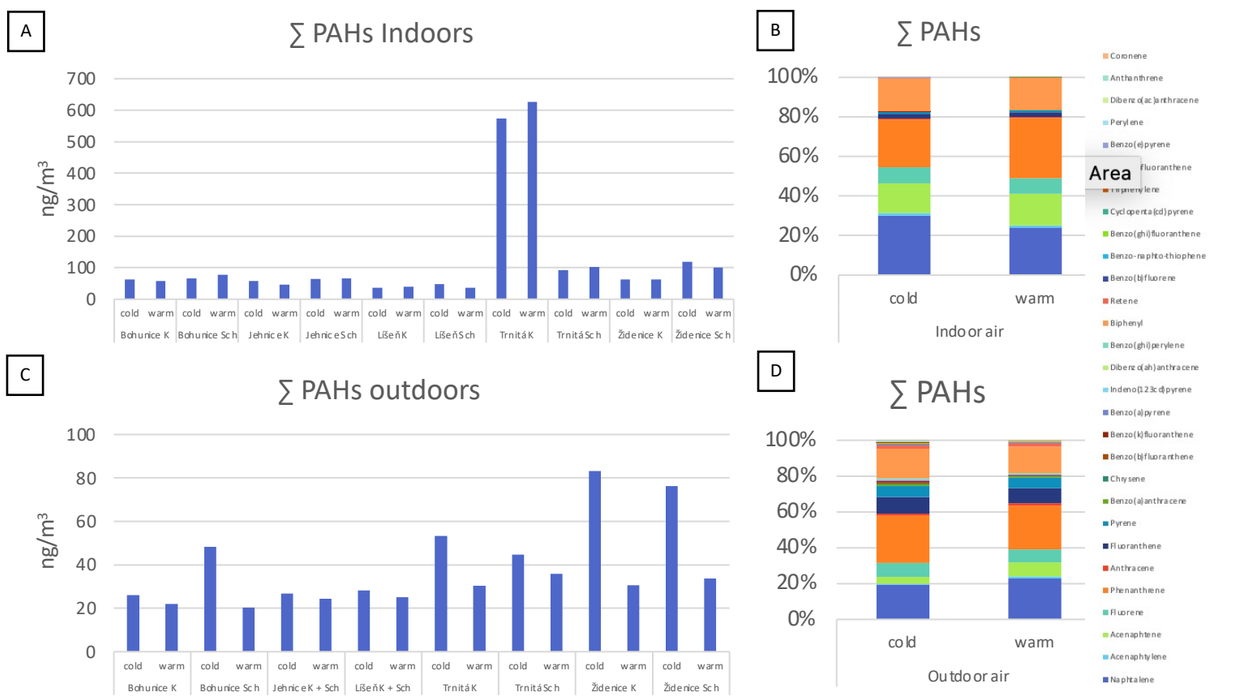

Figure 3: Comparison of the total PAHs measured in schools and kindergartens around Brno region. A) Total PAHs measured in the indoor air during a cold and warm season at 5 different areas in Brno. B) PAHs composition in indoor air during a cold and warm season. C) Total PAHs measured in the outdoor air during a cold and warm season at 5 different areas in Brno. D) PAHs composition in the outdoor air during a cold and warm season.

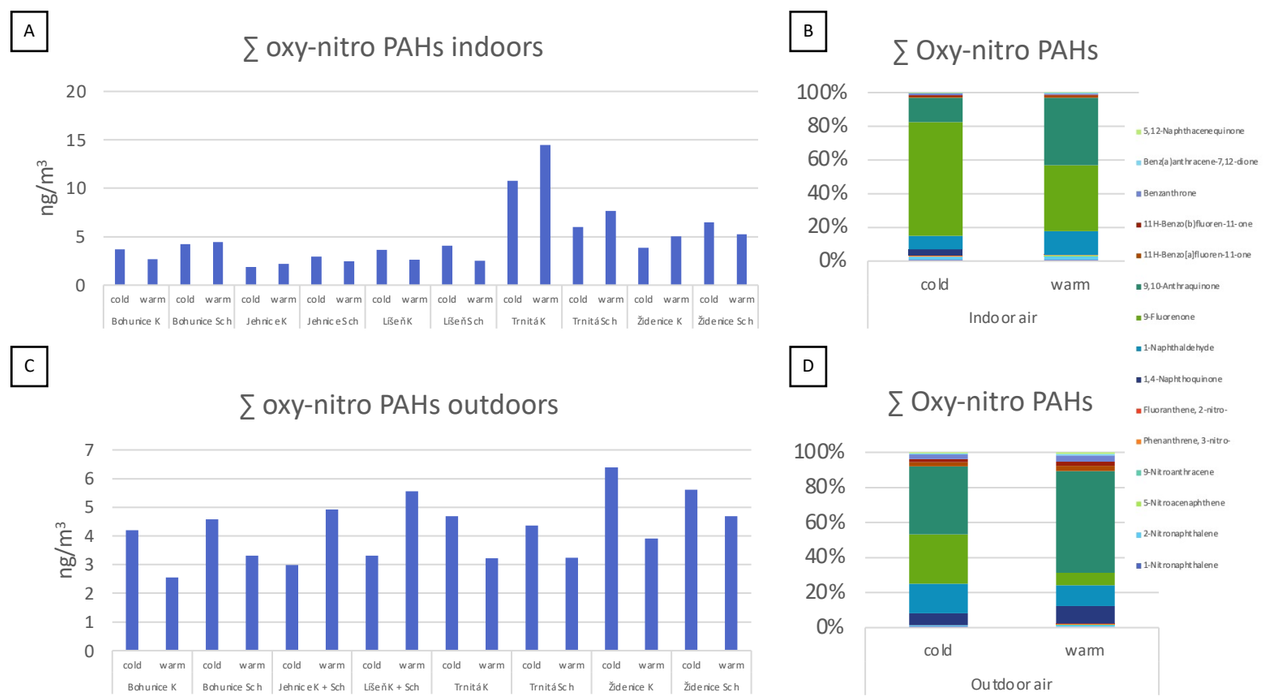

Figure 4: Comparison of the total oxy-nitro PAHs measured in schools and kindergartens around Brno region. A) Total oxy-nitro PAHs measured in the indoor air during a cold and warm season at 5 different areas in Brno. B) Oxy-nitro PAHs composition in indoor air during a cold and warm season. C) Total oxy-nitro PAHs measured in the outdoor air during a cold and warm season at 5 different areas in Brno. D) Oxy-nitro PAHs composition in the outdoor air during a cold and warm season.

Results

- Low molecular weight PAHs (naphthalene, biphenyl, acenaphthene, phenanthrene) dominated in indoor air during both the cold and warm season, while outdoor air had a higher contribution from fluoranthene and pyrene (Fig. 3B, 3D)
- 9-fluorenone and 9,10-anthraquinone were the dominant oxy-PAHs in indoor and outdoor air during both the cold and warm season (Fig. 4B, 4D)
- Trnitá kindergarten had much higher concentrations of PACs in indoor air during both the warm and cold season compared to other sites (Fig. 3A, 4A), but outdoor levels were not similarly elevated (Fig. 3C, 4C). This suggests unique indoor sources of PAHs at this kindergarten.
- Outdoor concentrations of all PAHs and most oxy-nitro PAHs were higher in the cold period, due to higher emissions, reduced photodegradation and less atmospheric mixing (Fig, 3C, 4C).
- The concentrations of all PAHs and oxy-nitro PAHs are higher in the indoor environment, attributed to indoor sources and enhanced concentration of PAHs from outdoors due to limited indoor photodegradation.

Future Work

The initial analysis of this data identified a link between urban outdoor sources of PAHs, indoor sources, and properties of the indoor environment that enhance PAC concentrations relative to outdoor. Future analysis will focus on evaluating children's exposure to PACs and linking PAC levels with indoor and outdoor air quality measurements, particularly PM_x.

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References

[1] Naumova, Y.Y. *et al. Environ. Sci. Technol.* 2002, 36, 12, 2552-2559, https://pubs.acs.org/doi/full/10.1021/es015727h, [2] Li, C.S. *et al. Atmospheric Environment,* 2000, 34, 4, 611-620, https://doi.org/10.1016/S1352-2310(99)00171-5, [3] Dubowski S. D. *et al. Journal of Exposure Analysis and Environmental Epidemiology,* 1999, 9, 312-321, https://www.nature.com/articles/7500034.pdf

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