Physical and chemical characterization of indoor particle sources

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Introduction

The hazardousness of indoor particle sources is widely known. Indeed, the human exposure in indoor environments characterized by indoor sources with high emission rates can lead to the occurrence of different diseases, including cancer. The carcinogenic effect is due to the transportation of chemical compounds (e.g., heavy metals or polycyclic aromatic hydrocarbons) in different aerosol metrics [1].

To date, the lack of studies that contextually characterize the physical and chemical composition of indoor particle aerosol sources and, especially, in the sub-metric range, suggests investigating this field.

In this work, a physical and chemical characterization for different indoor sources (e.g., candles, incenses and mosquito coils) was conducted.

Methodology

Physical analysis

Emission factors [2]

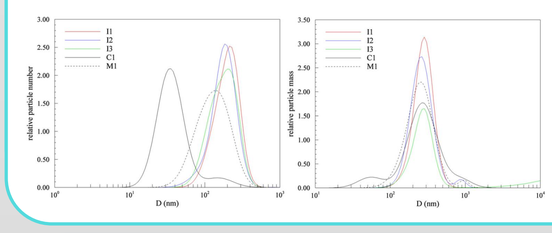
- Number (part./h) (CPC 3775, TSI Inc.)
- PM_{10} (mg/h) (DustTrak, TSI Inc.)

	Candles	Incenses	Mosquito coils
Number (part./h)	4.07-4.85×10^{13}	4.54-10.8×10^{14}	2.92-4.57×10^{14}
PM_{10} (mg/h)	4.02-89.5×10^{-2}	6.18-7.28×10^{1}	4.88-10.1×10^{2}

$$EF = V\left[\frac{C_{in} - C_{in,0}}{\Delta t} + \overline{(AER + k)} \cdot \overline{C_{in}} - AER \cdot C_{in,0}\right]$$

Particle Size Distributions [2] (EC 3081, CPC 3775, SMPS 3696 TSI Inc.)

- Number (dN/dlogDp)
- Mass (dM/dlogDp)



Sampling

Test chamber 3.14 m³

Physical measurements

EC 3081, TSI Inc.

CPC 3775, TSI Inc.

DustTrak, TSI Inc.

Sources

Candles

Incenses

Mosquito coils

Chemichal measurements

DEKATI ELPI®+

LOW PRESSURE IMPACTOR

- Sampling Flow rate: 10 lpm
- 14 impactor stages electrically detected + 1 pre-separator stage (D_p=10 µm)
- Greased polycarbonate substrates
- Sampling time for particle mass collection ≈ 4 h

Chemichal analysis

GC/MS

- **IPA detection and quantification**

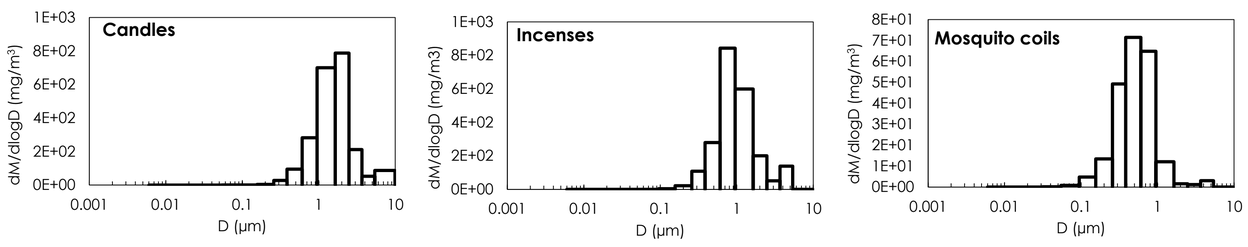
Filter → Extraction (n-heptane) (2 mL + USAE (6 min)) → 0.5 mL → 2 times GC-MS (Finningan TraceGC ultra)

ICP-AES

- **Metal detection and quantification**

Filter → Mineralization (HNO_3) (Power = 600 W, Time = 20 min) → 10 mL → Microwave digester ICP-MS (Agilent Techonologies)

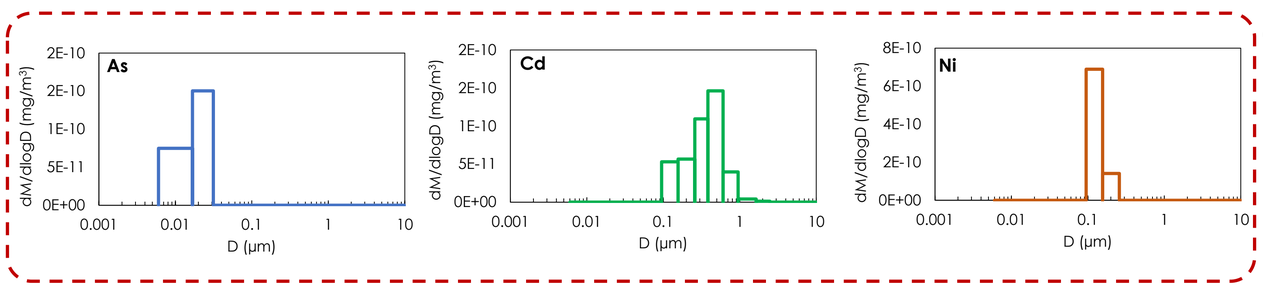
Results and Discussion



- The combustion of **candles**, **incenses** and **mosquito coils** is responsible for the emission of airborne particles, especially in the sub-metric range (D_p<1µm). The chemical analyses conducted with ELPI impactor show the presence of different hazardous chemical compounds;

	Carcinogenic compounds, Group 1			2A	2B	3	n.c.
	As	Cd	Ni	Pb	Sb	Cu	Zn
Candles	-	-		4.90×10^{-6}	3.21×10^{-5}	1.30×10^{-5}	5.46×10^{-5}
Incenses	-	-		1.65×10^{-6}	7.42×10^{-6}	4.29×10^{-6}	1.90×10^{-5}
Mosquito coils	**2.94×10^{-6}**	**1.05×10^{-6}**	**8.98×10^{-7}**	9.63×10^{-6}	6.79×10^{-5}	6.64×10^{-6}	3.15×10^{-5}

- The mass fraction of metal compounds is not negligible and is comparable with the results already found in other research studies, such as particles emitted by wood and pellet combustion sources [4];



- Group 1 carcinogenic compounds [3] were detected as a result of the **mosquito coil** combustion. In particular, **As**, **Cd** and **Ni** were collected in the sub-micrometric range of the mass particle distributions even down to few nanometers.

- Considering that the **sub-metric particles** are the main responsible for the probability of getting **lung cancer** [1], these results are noteworthy and helpful for the application of the risk assessment models.

[1] Caracci, E., Stabile, L., & Buonanno, G. (2021). A simplified approach to evaluate the lung cancer risk related to airborne particles emitted by indoor sources. *Building and Environment*, *204*, 108143.
[2] Stabile, L., Fuoco, F. C., & Buonanno, G. (2012). Characteristics of particles and black carbon emitted by combustion of incenses, candles and anti-mosquito products. *Building and Environment*, *56*, 184-191.
[3] IARC. A Review of Human Carcinogens, Part F: Chemical agents and related occupations. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 100F, 2012b.
[4] Stabile, L., Buonanno, G., Avino, P., Frattolillo, A., & Guerriero, E. (2018). Indoor exposure to particles emitted by biomass-burning heating systems and evaluation of dose and lung cancer risk received by population. Environmental pollution, 235, 65-73.

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