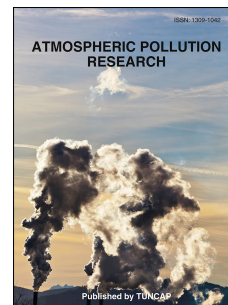


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Indoor and outdoor air quality: a university cafeteria as a case study

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Abstract: A short but exhaustive air sampling campaign was conducted in a university cafeteria, an occupational environmental not yet studied. Carbonyls and volatile organic compounds were collected by passive diffusion samplers. Temperature, relative humidity, CO₂, CO and particulate matter were continuously monitored indoors and outdoors. Simultaneous PM₁₀ sampling with high and low volume instruments, equipped with quartz and Teflon filters, respectively, was performed during working hours and at night. The quartz filters were analysed for their carbonaceous content by a thermo-optical technique and organic constituents by GC-MS. Water-soluble ions and elements were analysed in the Teflon filters by ion chromatography and PIXE, respectively. Low air change rates (0.31-1.5 h⁻¹) and infiltration factors of 0.14, for both PM_{2.5} and PM₁₀, indicate poor ventilation conditions. Concentrations of both gaseous pollutants and particulate matter were much higher in the cafeteria than outdoors, showing strong variations throughout the day depending on occupancy and activities. The average concentration of indoor-generated PM₁₀ was estimated to be 32 µg m⁻³. Organic compounds in PM₁₀ included alkanes, PAHs, saccharides, phenolics, alcohols, acids, alkyl esters, triterpenoids, sterols, among others. The complex particle composition reveals the multiplicity of sources, formation reactions and removal processes, not yet fully known, and suggests the contribution from dust resuspension, abrasion and off-gassing of building materials, cooking emissions, tobacco smoke, and several consumer products. Many compounds are in the list of ingredients of personal care products, pesticides, plasticisers, flame retardants and psychoactive drugs. The inhalation cancer risks of metals and PAHs were found to be negligible.

Keywords: Cafeteria, Indoor air quality, PM₁₀, Metals, Organic compounds, Sources

38 1. Introduction

39

40 In recent decades, Indoor Air Quality (IAQ) has been the focus of attention by the scientific
41 community, governments and international organisations (Abdul-Wahab et al., 2015). It is a known
42 fact that we spend more than 90% of our time indoors and that the levels observed are often higher
43 than those recorded outdoors. Thus, the health risks from exposure to indoor air pollution may be
44 larger than those associated with outdoor pollution. Poor IAQ can be especially detrimental to
45 vulnerable groups such as children, young adults, the elderly, or those suffering from chronic
46 respiratory and/or cardiovascular diseases (Cincinelli and Martellini, 2017). Furthermore, IAQ in the
47 workplace is important because employees are occupationally exposed on a regular basis to a variety
48 of pollutants with potential impact on comfort, work-related health problems, sickness absence, and
49 productivity (Al horr et al., 2016; Carrer and Wolkoff 2018; Śmiełowska et al., 2017). IAQ in elderly
50 care centres (e.g. Almeida et al., 2016; Bentayeb et al., 2015; Buczyńska et al., 2014; Mendes et al.,
51 2015; Mui et al., 2008; Simoni et al., 2003), office buildings (e.g. Mandin et al., 2017; Śmiełowska et
52 al., 2017; and references therein) and schools (e.g. Alves et al., 2013; Barmpareos et al., 2018;
53 Bennet et al., 2019; Blondeau et al., 2005; Chatzidiakou et al., 2015; Fuoco et al., 2015; Kalimeri et
54 al., 2016; Madureira et al., 2016; Yang et al., 2015) has been extensively investigated. Some studies
55 were also conducted to evaluate the IAQ in restaurants with different cooking styles (Dai et al., 2018;
56 Lee et al., 2001; Lee et al., 2011; Elsharkawy and Javed, 2018; Mugica et al., 2001; Sofuoglu et al.,
57 2015; Taner et al., 2013; Wilson et al., 2011).

58 Restaurants not only have many of the same threats generally observed in office buildings, but
59 they also encompass several other pollutants given off by cookware, open flames, cooking appliances,
60 refrigeration units, strong chemical degreasers and aggressive cleaning solvents. Most of the
61 published studies report the monitoring of comfort parameters, ventilation and/or some regulated
62 pollutants. Gaseous compounds (CO, CO₂, NO_x and some volatile organic compounds), particles less
63 than 2.5 and 10 µm in diameter (PM_{2.5} and PM₁₀, respectively), as well as some organic compounds in
64 the particulate phase, normally from the group of polycyclic aromatic compounds (PAHs) with
65 proven carcinogenic properties, are the most commonly monitored pollutants (Abdullahi et al., 2013;
66 Marć et al., 2018; and references therein).

67 University cafeterias, a specific type of eating establishment, are popular meeting places for
68 students and staff, providing space for leisure, relaxation and a room to have a quick lunch or snack.
69 For this category of restaurant, as far as we know, no exhaustive evaluation has been made. Using
70 optical counters, Zhao et al. (2010) measured PM concentrations in three different cafeterias located at
71 Tsinghua University, Beijing, China. However, no information is given on the chemical composition
72 of the particles and on the concentration of other pollutants. Hsu and Huang (2013) conducted a study
73 in the student cafeteria at Chia-Nan University in southern Taiwan. Measurements of relative
74 humidity, temperature, airflow velocity, CO₂ and total suspended particles were made, although the

75 focus of the work was not centered on IAQ but rather on the efficiency of two disinfection treatments
76 in removal of microorganisms.

77 This paper describes and discusses a short case study on a comprehensive air quality monitoring
78 programme carried out in a university cafeteria. Besides the measurement of traditional parameters,
79 such as regulated gaseous pollutants, the work had as main objective the detailed characterisation of
80 PM_{10} , including organic and inorganic components, in order to understand which sources and
81 processes contribute to the measured levels and to estimate the carcinogenic and non-carcinogenic
82 risks associated with inhalation of elements and PAHs by employees and customers. This preliminary
83 study can serve as a basis for improving future monitoring campaigns, especially as regards the
84 definition of source-marking chemical species, and for defining mitigation strategies to reduce
85 exposure to pollutants in similar facilities.

86

87 **2. Methodology**

88

89 **2.1. Sampling**

90

91 A one-week extensive sampling campaign was carried out from 27th November to 1st December
92 2017 at the León (Spain) university cafeteria. The commercial establishment is continuously open for
93 12 hours (7:00-19:00, UTC) from Monday to Friday. The cafeteria is one large open room (410 m²)
94 with fourteen tables, each capable of seating four to eight people, three standing round tables and
95 stools along the 21 m long bar (Fig. 1). A separate kitchen provides the space to prepare the daily
96 special menus and several dishes of fast food, such as burgers, sandwiches and French fries. The
97 kitchen is equipped with a diesel fired range cooker, electric grills and toasters. The extractor hood of
98 the kitchen has 4.8 × 2.4 m. There is no information regarding the brand, model or power. The
99 cafeteria has two entrance doors, one opening to an adjacent alley and the other opening to an outdoor
100 patio. A heat pump works as heater during the colder months and as air conditioner during the warmer
101 months. Attendance indoors was highly variable, depending on the time of the day. Officially, the
102 maximum occupancy allowed is 140 persons. People occupancy was logged manually throughout the
103 campaign. In general, in the early morning, there was a simultaneous presence of 10 to 20 people,
104 reaching a peak at lunch time (60 to 100 people). During the afternoon, the frequency of attendance
105 varied from 10 to 40 clients, with a maximum around 16:00.

106 Temperature, relative humidity, CO₂ and CO were continuously monitored with air quality probes
107 inside (TSI, model 7545) and outside (Gray Wolf[®], WolfSense IQ-610) the cafeteria. Real-time laser
108 photometric instruments (TSI, DustTrak DRX 8533) were used to record particulate matter (PM_1 ,
109 $PM_{2.5}$ and PM_{10}) concentration profiles over time in the indoor and outdoor environments,
110 simultaneously. All these continuous monitoring instruments were operated with 1-min resolution and
111 were factory-calibrated before use. Simultaneous sampling with two PM_{10} high volume air MCV

112 (model CAV-A/mb) instruments for gravimetric quantification was carried out on pre-weighed 150
113 mm quartz fibre filters (Pallflex®). The equipment was operated at a flow of $30 \text{ m}^3 \text{ h}^{-1}$. Samples were
114 collected during the opening hours, simultaneously indoors and outdoors. Night time samples were
115 also taken in order to compare the PM levels during occupancy and non-occupancy periods.
116 Furthermore, PM_{10} samples were collected on Teflon membrane filters (47 mm diameter, Pall
117 Corporation) with a TCR TECORA (model 2.004.01) operated at a flow of $2.3 \text{ m}^3 \text{ h}^{-1}$. The
118 gravimetric quantification was performed with an analytical balance (Mettler Toledo, XPE105
119 DeltaRange®). Due to the possibility of vandalism and unfavourable weather conditions, with
120 freezing temperatures, the outdoor equipment was shut down and sheltered at night. Thus, outdoor
121 measurements correspond to the occupancy period in the cafeteria. All the data were registered in
122 UTC.

123 Passive sampling of formaldehyde and acetaldehyde was done using Radiello™ diffusion tubes
124 filled with 2,4-dinitrophenylhydrazine (2,4-DNPH) coated FLORISIL® over one week of continuous
125 exposure, simultaneously indoors and outdoors. Aldehydes react with 2,4-DNPH to give the
126 corresponding 2,4-dinitrophenylhydrazones. Volatile organic compounds (VOCs) were also collected
127 with passive samplers from Radiello™. To verify if there were large variations in the carbonyl and
128 VOC levels, passive sampling was repeated two more times in the weeks following the campaign
129 described above.

130

131 **2.2. Chemical analyses**

132

133 After gravimetric determinations, thermal-optical analysis of PM_{10} quartz filters was performed to
134 obtain the carbonaceous content (organic and elemental carbon, OC and EC). This method is based on
135 the CO_2 quantification, by a non-dispersive infrared (NDIR) analyser, which is released from the
136 volatilisation and oxidation of different carbon fractions under controlled heating. A laser beam and a
137 photodetector that measure the filter light transmittance allow separating the EC formed by OC
138 pyrolysis from the one that was initially in the filter (Alves et al., 2011).

139 Two circular punches of 47 mm from the quartz filters were sequentially extracted with
140 dichloromethane and methanol. The resulting extract was separated into five different organic
141 fractions by flash chromatography with silica gel and various solvents of increasing polarity. To meet
142 the detection limits required by the speciated organic compounds, the night sampling filters were
143 combined and extracted together. Thus, an average composition was obtained for non-occupancy
144 periods at night. After each elution, the different fractions were concentrated in a TurboVap system
145 from Biotage and evaporated to dryness by a nitrogen stream. Before chromatographic analysis, the
146 fractionated extracts containing polar compounds were derivatised to trimethylsilyl ethers. All the
147 extracts were analysed by gas chromatography-mass spectrometry (GC-MS). A detailed description of

148 the whole procedure for the speciation of organic compounds was previously reported by Alves et al.
149 (2011).

150 Half of each Teflon filter was extracted with ultrapure Milli-Q water for ion chromatography
151 analysis. A detailed description of the method can be found elsewhere (Vicente et al., 2018). All the
152 elements with $Z > 10$ were determined in the other half of the filters by proton-induced X-ray
153 emission (PIXE) (Lucarelli et al., 2014).

154 The carbonyl-DNPH derivatives were extracted from the Radiello tubes with 2 mL of acetonitrile
155 for 30 min, filtered through a micropore filter membranes with porosity of 0.45 μm , and analysed by
156 high performance liquid chromatography. HPLC measurements were carried out with a Jasco PU-980
157 pump, a Rheodyne 7125 six-port valve with a 20 μL loop and a Jasco MD-1510 diode array detector.
158 An isocratic mixture of acetonitrile and water (60:40), at a flow rate of 1.5 mL min^{-1} , was used to
159 separate the 2,4-DNPH on a Supelcosil™ LC-18 column (5 μm particle size; $L \times \text{I.D.}$: 250 \times 4.6 mm).
160 The carbonyl concentrations were quantified with external calibrations curves constructed from
161 standard solutions of carbonyl-DNPH derivatives in acetonitrile. The UV wavelength for detection
162 was 360 nm. VOCs in activated charcoal cartridges were chemically desorbed with 2 mL of carbon
163 disulphide (CS_2) and 100 μL of internal standard (2-fluorotoluene) for 30 min and analysed by gas
164 chromatography coupled to flame ionisation detector (GC-FID), following the conditions described in
165 Pegas et al. (2010).

166

167 2.3. Air change rates

168

169 In the present study, the air change rates per hour (ACR, h^{-1}) were estimated by the CO_2
170 concentration decay method (Alves et al., 2013). For a well-mixed space, the change in CO_2
171 concentration with time is given by:

172

$$173 \quad C_t = C_{ext} + \frac{q_{\text{CO}_2} \times 10^6}{Q} - \left(C_{ext} - C_0 + \frac{q_{\text{CO}_2} \times 10^6}{Q} \right) e^{\left(\frac{-Qt}{V} \right)} \quad (1)$$

174

175 where C_t is the indoor concentration of CO_2 at time t (ppm), C_{ext} is the outdoor concentration of CO_2
176 (ppm), C_0 is the concentration of CO_2 in the indoor air at time 0 (ppm), Q is the volume flow rate of
177 air entering the space ($\text{m}^3 \text{s}^{-1}$), q_{CO_2} is the volumetric indoor emission rate of CO_2 ($\text{m}^3 \text{s}^{-1}$), V is the
178 volume of the room (m^3) and t is the interval since $t = 0$ (s). When the room is unoccupied there is no
179 CO_2 emission from the occupants, and $q_{\text{CO}_2} = 0$. Thus, Eq. (1) can be rearranged to give the following
180 expression, which allows the ventilation rate (Q) to be estimated from measured concentration values
181 time t apart:

182

$$Q = -\frac{V}{t} \times \ln \left(\frac{C_t - C_{ext}}{C_0 - C_{ext}} \right)$$

184 (2)

185

186 The air change rate is defined as:

187

$$ACR = \frac{Q}{V}$$

189 (3)

190

191 **3. Results and discussion**

192

193 **3.1. Comfort parameters and gaseous pollutants**

194

195 The indoor thermal environment is not only related to energy use in buildings, but is also linked to
 196 human satisfaction and wellbeing, health outcomes, and productivity. While temperature is the most
 197 influential factor in generating a phenomenological sense of thermal comfort, relative humidity (RH)
 198 contributes to a combined effect on the occupants' perception. Relative humidity levels below 25%
 199 are associated with increased discomfort and drying of the mucous membranes and skin, which can
 200 lead to chapping and irritation. Low relative humidity also increases static electricity, which can
 201 hinder the operation of computers and other equipment. High humidity levels can result in
 202 condensation within the building structure, providing the conditions for dust mite, mould and bacteria
 203 populations to grow. These, in turn, can cause respiratory problems and/or allergic reactions.
 204 Increasing RH is also associated with enhanced off-gassing of VOCs from building materials (Huang
 205 et al., 2016). The American Society of Heating, Refrigerating, and Air-Conditioning Engineers
 206 (ASHRAE Standard 55-2004) proposed indoor temperatures from 20 to 23 °C in the autumn/winter
 207 season, while the recommended RH values are in the 30–60% range for optimum comfort. The inter-
 208 daily variations (mean±SD) of temperature during the occupancy periods were weak, ranging from
 209 19.2±1.7 to 20.0±1.0 °C, while RH fluctuated between 31.2±2.8 and 36.1±5.3% (Fig. 2). Outside, the
 210 daytime temperatures and RH oscillated between -5.8 and 6.5 °C and from 46.2 to 90.9%,
 211 respectively.

212 CO₂ at the concentrations usually observed in buildings is not a direct health risk, but its levels can
 213 be used as an indicator of occupant odours (bioeffluents). CO₂, primarily generated through human
 214 metabolism, provides a good indication of air change rates. Its build up in indoor environments is
 215 attributed to inefficient ventilation. ASHRAE (Standard 62.1-2016) reports that while not necessarily
 216 hazardous, the amount of CO₂ in an indoor environment should remain under 1,000 ppm. The mean
 217 daytime carbon dioxide concentration indoors was 891±226 ppm, decaying to values around 400 ppm
 218 at night. A twofold difference in indoor concentration was observed between occupancy and non-

219 occupancy periods. Concentrations recorded throughout the weekend were similar to those observed
220 in nocturnal periods. The inter-day fluctuations depended on the occupancy rates, reaching a
221 maximum concentration of 3430 ppm in the early evening of Thursday (Fig. 2), the day the cafeteria
222 closed later due to a party attended by about 150 people.

223 ACR ranged between 0.31 and 1.5 h⁻¹, indicating poor ventilation conditions. For all spaces in
224 general, a minimum ACR of 4 h⁻¹ is recommended, while specific values of 8-12 h⁻¹ and 12-15 h⁻¹ are
225 suggested for restaurants and cafeterias, respectively (The Engineering ToolBox, 2005). Natural
226 ventilation can be challenging during the wintertime in cooler climates. While open windows and
227 doors can bring fresh air inside, this action obviously allows heat to escape. The installation of
228 heating, ventilation, and air conditioning (HVAC) technologies may be the only solution to assure
229 ventilation requirements for acceptable IAQ and thermal comfort.

230 Carbon monoxide levels were very low indoors. The maximum concentration ever recorded was
231 1.1 ppm. All the doors and windows were kept closed, due to the cold weather outside, preventing CO
232 infiltration into the cafeteria from the nearby low traffic street and doorstep smokers. Low
233 concentrations, always < 3 ppm, were also observed outdoors. ASHRAE (Standard 62.1-2016) lists a
234 maximum allowable short-term limit of 9 ppm for CO in indoor air, while the WHO (2010)
235 recommends CO concentrations based on exposure time ranging from 90 ppm (15-minute exposure)
236 to 10 ppm (8-hour exposure). The American Conference of Governmental Industrial Hygienists
237 (ACGIH) has assigned CO a threshold limit value (TLV) of 25 ppm as a time weighted average
238 (TWA) for a normal 8-hour workday and a 40-hour workweek. The ACGIH limit is based on the risk
239 of elevated carboxyhemoglobin levels. The National Institute for Occupational Safety and Health
240 (NIOSH) has established a recommended exposure limit of 35 ppm as an 8-hour TWA and 200 ppm
241 as a ceiling, based on the risk of cardiovascular effects.

242 Formaldehyde and acetaldehyde, two ubiquitous compounds emitted by combustion processes,
243 meat cooking operations and consumer products, presented indoor mean concentrations of 8.8 and
244 17.8 µg m⁻³, respectively, while the corresponding outdoor values were 1.3 µg m⁻³ and of the same
245 order of the blanks. The inter-week variations were always <10%. Formaldehyde was below the air
246 quality guideline of 100 µg m⁻³ (as a 30-min average value) recommended by the World Health
247 Organisation (WHO) in 2010. However, short-time exceedance of this guideline level might have
248 occurred in the indoor environment. Acetaldehyde was included by the WHO in Group 2, which
249 encompasses pollutants of potential interest, but further investigation would be needed before it is
250 clear whether there is enough evidence to warrant their inclusion in the guidelines. However, based on
251 studies of short- and long-term exposure, countries such as Canada have set a maximum daily limit of
252 280 µg m⁻³.

253 The indoor levels of VOCs (Table 1) were higher than those observed outdoors. Among these,
254 ambient concentrations of benzene are regulated by law due to its toxicity (European Commission,
255 2009). In contrast, indoor levels of VOCs are not subject to any legislation. Of all the VOCs found in

256 buildings, BTEX (benzene, toluene, ethyl benzene, o-, m-, and p-xylene) are among the most
257 common. Indoors, these compounds can originate from multiple sources, including building materials
258 (paints, varnishes), consumer products (cleaning agents, fingernail polish, lacquers, adhesives), and
259 human activities (smoking and combustion). In outdoor air, traffic is pointed out as a major source.
260 The outdoor concentrations of benzene were far below the annual ambient air quality standard of $5 \mu\text{g m}^{-3}$
261 m^{-3} set by the European Commission. Previous studies have reported the indoor BTEX levels at
262 homes (Dai et al., 2017; Esplugues et al., 2010; Fan et al., 2018; Liu et al., 2013), libraries (Cincinelli
263 et al., 2016), schools (Demirel et al., 2014; Pegas et al., 2011; Raysoni et al., 2017), printing shops
264 and photocopy centres (El-Hashemy and Ali, 2018), and a confined parking area (Castro et al., 2015).
265 Highly variable concentrations, up to hundreds of $\mu\text{g m}^{-3}$, have been obtained, depending on the
266 source strengths. Benzene levels of 18.4, 10.0, 9.3 and $3.7 \mu\text{g m}^{-3}$ were measured in the dining areas
267 of a Korean barbecue style restaurant, a Chinese hot pot restaurant, a Chinese dim sum restaurant and
268 a Western canteen, respectively (Lee et al., 2001). The corresponding values reported for toluene were
269 156.1, 93.8, 81.6 and $17.6 \mu\text{g m}^{-3}$. In the present study, *n*-butanol and toluene were the VOCs with the
270 highest indoor air concentrations. Butanol (or butyl alcohol) is present in many foods and beverages
271 and is also used in a wide range of consumer products, such as cleaning products or cosmetics.
272 Toluene is commonly added to gasoline and can enter the indoor spaces from outside. Toluene is also
273 often used as solvent and can be released from a variety of products found in homes, including paints
274 and other finishes, adhesives, and some personal care products. It is also found in tobacco smoke.
275 Although detected at lower concentrations compared to these two VOCs, *n*-hexane showed very high
276 I/O ratios (up to 13), suggesting the presence of active sources in the cafeteria. This aliphatic
277 compound is primarily used as a solvent and as a component of certain glues and adhesives, cleaning
278 agents, biocidal products, ink and toners, textile dyes, perfumes, fragrances and cosmetics (Federal
279 Institute for Occupational Safety and Health, 2017). It is also present in volatile fractions of various
280 plant species, such as apples and orange juice (Toxno, 2018). Moreover, Ahearn et al. (1996) reported
281 that a variety of fungi found in buildings are capable of releasing gases that include *n*-hexane.

282

283 **3.2. Particulate matter**

284

285 **3.2.1. Mass concentrations**

286

287 From the gravimetric measurements, average PM_{10} concentrations of 35.6 ± 5.6 , 12.4 ± 3.4 and
288 $23.3 \pm 10.0 \mu\text{g m}^{-3}$ were recorded indoors during the occupancy and non-occupancy hours, and in
289 the outdoor air, respectively, not exceeding the 24-h guideline of $50 \mu\text{g m}^{-3}$ set by the WHO.
290 However, the real-time data collected by the photometric monitors show strong variations throughout
291 the day. The highest values were reached at morning snack and lunch time, when the influx of
292 students and staff was typically higher. Throughout the week, the maximum $\text{PM}_{2.5}$ and PM_{10} values

293 were in the ranges 44-92 and 62-136 $\mu\text{g m}^{-3}$, but peaks as high as 2560 and 2710 $\mu\text{g m}^{-3}$, respectively,
 294 were registered in late afternoon and early evening of the day of a student party, during which even
 295 some firecrackers were launched Fig. 3). Throughout the week, a peak was observed between 19:00
 296 and 20:00, time at which cleaning activities of the premises took place. Fine particles represented an
 297 overwhelming proportion of PM_{10} indoors: $\text{PM}_{2.5}/\text{PM}_{10}=0.82-0.91$ (avg=0.88) and $\text{PM}_1/\text{PM}_{10}=0.81-$
 298 0.91 (avg=0.87). The $\text{PM}_{2.5}/\text{PM}_{10}$ and $\text{PM}_1/\text{PM}_{10}$ ratios were even higher outdoors, denoting the
 299 dominance of fine aerosols: $0.92-0.97$ (avg=0.95) and $0.91-0.97$ (avg=0.94). Regardless of particle
 300 size, indoor concentrations were 1.5-2 times greater than those found in outside air. During the night,
 301 in the cafeteria, the concentrations drop approximately 3 times.

302 The infiltration factor, which represents the equilibrium fraction of the outdoor PM that penetrates
 303 indoors and remains suspended (Othman et al., 2019), was calculated as follows:

$$305 \quad C_{\text{in}} = F_{\text{inf}} \times C_{\text{out}} + C_{\text{ig}} \quad (4)$$

306
 307 where C_{in} and C_{out} are the indoor and outdoor $\text{PM}_{2.5}$ or PM_{10} concentrations, F_{inf} is the infiltration
 308 factor, and C_{ig} represent the concentrations of indoor-generated particles. The slopes of the
 309 correlations between indoor and outdoor concentrations for the occupancy periods, i.e. the infiltration
 310 factors, were 0.14 for both $\text{PM}_{2.5}$ and PM_{10} . As inferred from the CO_2 measurements, the low particle
 311 infiltration factors denote air tightness. On average, concentrations of indoor-generated particles were
 312 $27 \mu\text{g PM}_{2.5} \text{ m}^{-3}$ and $32 \mu\text{g PM}_{10} \text{ m}^{-3}$. To evaluate the influence of outdoor particulate pollutants on
 313 indoor environment, the concept of contribution rate (ρ) was applied, as suggested by Lv et al. (2017):

$$315 \quad \rho = (F_{\text{inf}} \times C_{\text{out}})/C_{\text{in}} \times 100 \% \quad (5)$$

316
 317 The contribution rates of outdoor sources were estimated to be, on average, 17.7 and 16.1 % for $\text{PM}_{2.5}$
 318 and PM_{10} , respectively, whereas a major input from indoor sources was observed (82.3 and 83.9 %).

320 3.2.2. Chemical composition

321
 322 To obtain a PM_{10} mass balance (Fig. 4), the measured element concentrations were converted into
 323 the respective mass concentrations of the most common oxides (SiO_2 , Al_2O_3 , CaO , MgO , MnO ,
 324 Fe_2O_3 , TiO_2 , K_2O , etc.). Because the GC-MS analyses indicated the presence of highly oxygenated
 325 compounds, to derive the organic matter content in PM_{10} , a total organic mass to organic carbon ratio
 326 (OM/OC) of 1.8 was adopted (Polidori et al., 2008). Total carbon ($\text{TC} = \text{OC} + \text{EC}$) accounted for 36.0
 327 ± 5.8 , 42.8 ± 7.9 and 27.6 ± 12.6 %wt. of the PM_{10} mass indoors during the occupancy and non-
 328 occupancy hours, and in the outdoor air, respectively (Fig. 5). Besides sampling and analysis artefacts
 329 affecting the attainment of chemical mass balance, the unaccounted mass can partly be explained by

330 the presence of unanalysed constituents. Furthermore, part of the unaccounted PM mass is usually
331 assigned to particle-bound water (Tsyro, 2005). On average, I/O ratios of 1.5 and 0.7 were obtained
332 for OC and EC, respectively, suggesting the presence of organic matter emitting sources in the
333 cafeteria, while elemental carbon is predominantly generated from combustion processes in the
334 outdoor environment. Mean OC/EC ratios of 7.5, 3.5 and 3.6 were observed for the occupancy and
335 night-time periods in the cafeteria and for the outdoor air, respectively. A much higher ratio (21.0)
336 was registered for the weekend daytime period. Lower EC infiltration rates over the weekend due to
337 the fact that the building is closed, absence of indoor EC sources (e.g. toasting bread) and off-gassing
338 of VOCs from surfaces leading to secondary organic aerosol formation, may justify the higher
339 proportion of OC compared to EC. It should be noted that OC and EC concentrations decreased from
340 10.7 and 1.1 $\mu\text{g m}^{-3}$ in the periods of occupation to 6.1 and 0.29 $\mu\text{g m}^{-3}$ in the weekend, respectively.

341 On average, water-soluble ions accounted for PM₁₀ mass fractions of 6.0, 15.8, 13.4, and 1.3 %
342 during the occupancy of the cafeteria, at night-time indoors, in the daytime period on the weekend
343 inside the building, and at regular working hours outdoors, respectively. Except for Ca²⁺ and K⁺, the
344 I/O ratios for all water-soluble ions were less than 1. The higher I/O ratios for Ca²⁺ and K⁺ may be
345 related to resuspension of fine dust from human movement. Concentration values in daytime were
346 higher than at night-time (Fig. 6). Together with chloride, the secondary ions sulphate, nitrate, and
347 ammonium were the dominant species. In addition to sea salt and biomass burning, chlorinated water
348 and cleaning products containing bleachers can release significant amounts of chloride. Ammonium
349 may also originate from cleaning products. For unknown reasons, in the outdoor sample of Tuesday,
350 concentrations increased approximately 4-fold compared to other days, contributing to a high standard
351 deviation. A good correlation between concentrations of total anions and total cations in PM₁₀ was
352 observed, but an anion deficit was registered. Non-measured organic ions, such as formate and
353 acetate, could contribute to the ionic balance. However, the anion deficit is most likely due to the
354 presence of non-determined carbonates (CO₃²⁻/HCO₃⁻) from resuspended local soil. Outdoors, the
355 molar ratio of NH₄⁺ to SO₄²⁻ was found to be greater than 2. This higher molar ratio suggests that in
356 addition to (NH₄)₂SO₄, NH₄NO₃ was formed because of excess quantity of NH₄⁺. Ammonium nitrate
357 is produced in the presence of high NH₄⁺ and HNO₃ concentrations, low temperatures and high
358 relative humidity. A mean NH₄⁺/SO₄²⁻ molar ratio of 1.6 was obtained indoors, indicating aerosols in
359 the form of (NH₄)₂SO₄ and NH₄HSO₄. Due to the higher temperatures indoors, NH₄NO₃ may
360 decompose to form NH₃ and HNO₃, which are then partially lost by deposition and sorption processes
361 to indoor surfaces, especially those with higher roughness, while another part reacts with NaCl and
362 Ca-containing particles. NaNO₃ and Ca(NO₃)₂ have low volatility compared to NH₄NO₃.

363 Both indoors and outdoors, the elements with highest concentrations were Na, Mg, Al, Si, S, Cl, K,
364 Ca and Fe (Table 2). Elements detected at I/O much higher than 1, suggesting indoor sources, were
365 Mg, P, K, Ca, Cr, Ni and Zn. Some of these elements (e.g. Ca, Mg, K) are present in mineral matter
366 and can be associated with soil dust that is brought in from outdoors on shoes. It has been shown that

367 resuspended dust contributes to the airborne particulate matter in the “personal cloud” (i.e. personal
368 breathing zone). Resuspension rates of settled dust depend on factors such as amounts accumulated,
369 floor characteristics, walking style, shoe types, humidity and cleaning activities (Rasmussen et al.,
370 2018). Some elements may result from abrasion of metallic components from furniture and other
371 building materials. Cr, for example, is an important alloying element in stainless steel and is also
372 present as chromated copper arsenate (CCA), a preservative for furniture and wood building materials
373 against insect, bacterial, and fungal decline (Rivas et al., 2015; and references therein). P is likely
374 associated with chlorinated phosphorus-based flame retardants and plasticisers, which are ubiquitous
375 in the indoor environment (Araki et al., 2014). Many metals (e.g. Ni and Zn) are also in the list of
376 ingredients of numerous personal care products (Borowska and Brzóška, 2015; Omenka and Adeyi,
377 2016).

378 Enrichment factors of each element with respect to crustal material (Wedepohl, 1995) were
379 calculated using Fe as reference element:

380

$$381 \quad EF = (X/Fe)_{\text{air}} / (X/Fe)_{\text{crust}} \quad (3)$$

382

383 where EF is the enrichment factor of element X, $(X/Fe)_{\text{air}}$ is the concentration ratio of X to Fe in the
384 PM_{10} samples, and $(X/Fe)_{\text{crust}}$ is the average concentration ratio of X to Fe in the continental crust.
385 Whether for samples of the cafeteria or for outdoor PM_{10} filters, EFs lower than 5 were obtained for
386 Na, Mg, Al, Si, K, Ca, Ti, V, Mn, Rb, Sr, Y and Zr, indicating a dominant soil dust origin. Although
387 the sampling campaign was carried out in winter, when the residential biomass combustion is a
388 common practice, the EFs for potassium do not reveal the dominance of wood or coal burning.
389 However, it should be borne in mind that residential combustion equipment is relatively inefficient,
390 reaching temperatures generally below 700-800 °C. It has been extensively reported that, before
391 condensing to form particles, potassium is released into the gas phase at temperatures above 727 °C
392 and that only the full combustion of biomass fuels at elevated temperatures (>1327 °C) is expected to
393 result in most of the potassium entering the gas phase (Mason et al., 2016). Compared to the dust-
394 derived elements, the EFs for S, Cl, Cu, Zn, As, Br, Mo and Pb were larger than 10, for both indoor
395 and outdoor samples, illustrating the influence of anthropogenic sources. Se was a particularly
396 enriched element with EF values > 1100. In addition to As and S, coal combustion is also a strong
397 emitter of Se. More than 20% of the total energy consumption in the region of León come from coal
398 combustion.

399 The emissions from coal burning increase during coldest months due to the use of domestic
400 heating and cooking devices (Blanco-Alegre., 2019). In outdoor environments, many of these
401 elements, in particular Cu, Zn, Pb and Mo, are mostly associated with traffic emissions (Pant and
402 Harrison, 2013). In dwellings and in working and leisure places, in addition to infiltration from
403 outdoors, these constituents can originate from the multiplicity of materials and consumer products

404 used indoors. Attention is drawn to the fact that the concentration of some elements has increased
405 sharply on the day of the student party. Potassium reached a level of 2140 ng m⁻³, while in other
406 occupancy periods concentrations ranged from 305 to 367 ng m⁻³. Cl, Zn and Cu increased from usual
407 levels in the ranges 214-396, 21-24 and 2.7-5.7 ng m⁻³ to values of 1870, 61 and 15 ng m⁻³,
408 respectively, on the party day. These elements are abundant constituents of tobacco smoke (Misha et
409 al., 1986), reason why there are suspicions that, although prohibited, this practice may have occurred
410 during the event.

411 The particulate matter organic extracts encompassed several aliphatics, polycyclic aromatic
412 hydrocarbons (PAHs), alcohols, acids, sterols, glycerol derivatives, phenolic compounds, saccharides,
413 among others. Aliphatic compounds included the homologous series of *n*-alkanes from C₁₁ to C₃₂ and
414 some alkenes. These are ubiquitous compounds in the environment with both natural and
415 anthropogenic origin. Alkane homologues were detected at I/O ratios ranging from 1.0 (dodecane) to
416 54 (dotriacontane). The sum of their concentrations was as follows: 49.4 ng m⁻³ (indoor, occupancy),
417 15.9 ng m⁻³ (indoor, night-time), 16.5 ng m⁻³ (outdoor, daytime), and 6.0 ng m⁻³ (indoor, weekend,
418 daytime). The maximum indoor concentration (13.4 ng m⁻³) was observed for dotriacontane. Alkenes
419 (C₁₄, C₁₆, C₁₈, C₂₀ and C₂₃) were present at I/O ratios from 3 to 5 and very low concentrations, peaking
420 in the cafeteria for hexadecene (0.47 ng m⁻³). Excepting hexadecene, alkenes were not detected in
421 samples from non-occupancy periods.

422 Figure 7 depicts the mean concentrations of individual PAHs in the cafeteria and outdoors.
423 Excluding naphthalene and acenaphthene, two volatile PAHs consisting of two benzene rings, the I/O
424 ratios for all other polyaromatics were always < 1. Contrary to many other compounds, the average
425 outdoor concentrations (7.8 ng m⁻³) was 3.3 times higher than those measured indoors (2.4 ng m⁻³).
426 Levels in the cafeteria dropped to 0.49 ng m⁻³ on the weekend, whereas the night-time value (4.3 ng
427 m⁻³) was between the one measured during working hours in the cafeteria and that registered outdoors.
428 Although nocturnal measurements in the ambient air were not carried out in the present study, outdoor
429 concentrations usually higher at night may have contributed to the build-up of PAHs in the cafeteria
430 through infiltration processes. Due to residential heating emissions, decreased atmospheric mixing
431 height and nocturnal atmospheric stability, an appreciable increase in concentrations in the evening is
432 likely to occur. On the other hand, at daytime, after emission by combustion sources (e.g. traffic),
433 PAHs undergo chemical transformations. Better dispersion conditions and atmospheric reactivity
434 during daytime, in general, lead to lower diurnal concentrations compared to nocturnal values. PAH
435 oxidative transformations in ambient air are supposed to be started by gas-phase OH and NO₃
436 radicals, followed by reactions with NO₂ and O₃ leading to ring-retaining quinones, nitro-PAHs and
437 ring-opened phthalic acids and their degradation products (Alam et al., 2015).

438 The homologous series of fatty alcohols from C₁₀ to C₃₀ was observed in the PM₁₀ samples (Table
439 3). 1-Hexacosanol and 1-octadecanol were the most abundant homologues. Their indoor
440 concentrations were more than 600 times higher than those measured outdoors. These *n*-alkanols are

441 constituents of many household and personal care products. Furthermore, octadecanol was identified
442 as one of the dominant compounds in fine organic aerosols from charbroilers and meat cooking
443 operations (Rogge et al., 1991). The homologous series of alkanolic acids (C_6 - C_{26}) and some alkenolic
444 acids were also present. In general, the concentrations recorded during the occupancy period in the
445 cafeteria far exceeded those observed outside. Palmitic, stearic and oleic were the dominant acids, in
446 agreement with previous studies describing cooking emissions (Abdullahi et al., 2013; He et al., 2004;
447 Rogge et al., 1991; Zhao et al., 2007).

448 Some dicarboxylic acids from C_4 to C_{16} , at I/O ratios generally higher than 1, were present in
449 PM_{10} , but at lower concentrations compared to those of fatty acids. He et al. (2004), who also detected
450 diacids in emissions from cooking processes at lower levels in comparison with alkanolic and alkenolic
451 acids, suggested that these compounds are formed by oxidation of dialdehydes during the autoxidation
452 process of unsaturated lipids. Among diacids, azelaic (C_9) was the most abundant in the cafeteria,
453 reaching concentrations up to 67 ng m^{-3} . The lab-engineered form of this acid is typically used in
454 skincare products. It is also an abundant compound in emissions from electronic cigarettes, heat-not-
455 burn tobacco products, and conventional cigarettes (Ruprecht et al., 2017). Biomass combustion is
456 also a source of diacids, in addition to emitting keto- (e.g. levulinic) and hydroxy-acids (e.g. glycolic,
457 glyceric and lactic) (Alves et al., 2011). All these acids were not detected in the outdoor samples or
458 were present in lower concentrations when compared to those observed inside the cafeteria. Liu et al.
459 (2017) measured a wide variety of carboxylic acids in a university classroom, indoors and outdoors,
460 including monoacids, diacids, hydroxy acids, carbonyl acids, and aromatic acids. Besides indoor
461 sources such as off-gassing of building materials, evidence for acid formation from indoor chemical
462 reactions with ozone was noticed. It was also suggested that human occupants may contribute to the
463 abundance of carboxylic acids either through direct emissions or surface reactions. Although
464 generally present at very low concentrations indoors, ozone may react with unsaturated organic
465 compounds present in skin and other materials. As observed in the university classroom, the elevated
466 indoor concentrations of lactic acid in the cafeteria during the occupancy period was likely human
467 perspiration. A recent study conducted in an art museum revealed the unexpected build-up of lactic
468 acid from sweat (Pagonis et al., 2019). It was found that this acid leaves the skin, travels through the
469 air, and sticks to the walls and other surfaces at high rates. It should be also noted that lactic and other
470 short chain acids (levulinic, glycolic, etc.) are frequently used in exfoliants, anti-wrinkle products and
471 other cosmetics. Thus, both the emission and partitioning mechanisms between the gas and the
472 particulate phases of these and many other compounds are complex and still far from being fully
473 understood.

474 Some resin acids were detected as PM_{10} -bound organic components: dehydroabietic, isopimaric,
475 abietic and podocarpic. Among these, dehydroabietic acid dominated. Its concentrations outside the
476 cafeteria exceeded those observed indoors, pointing to the residential burning of coniferous wood
477 (Vicente and Alves, 2018). Although it is an unlikely source in the cafeteria, it should be noted that

478 very high concentrations of free resin acids were detected in depilatory wax strips (Nilsson et al.,
479 2008).

480 Levoglucosan and its stereoisomers, mannosan and galactosan, were one of the dominant groups
481 of organic compounds. Levoglucosan has been recurrently used as a biomass burning tracer, since it is
482 a thermal degradation product of cellulose (Vicente and Alves, 2018). However, it was also detected
483 in particulate matter samples emitted from Sichuan, Dongbei, Hunan and Cantonese cooking styles,
484 suggesting that this anhydrosugar can also be generated during the heating process of vegetables (He
485 et al., 2004; Zhao et al., 2007). Mean I/O ratios lower than 1 reveal the strong impact of residential
486 biomass burning on the ambient air of the surroundings due to the low temperatures.

487 Many other monosaccharides, disaccharides, polysaccharides and polyols, were detected in PM₁₀.
488 However, due to structural isomerism and identical fragmentation patterns in the mass spectra, their
489 individual quantification was not possible. Thus, a mean response factor of the calibrated compounds
490 with the same functional groups was applied. A much higher indoor concentration for these
491 unidentified saccharides and a strong nocturnal decay was observed, suggesting that many of these
492 compounds were produced by the day-to-day activities of the cafeteria.

493 Many phenolic compounds and derivatives were detected in both indoor and outdoor samples.
494 These constituents are used in commercial or consumer products and in building materials. Methoxy-
495 and dimethoxyphenols, such as vanillic acid, sinapyl alcohol and syringic acid, are also found in
496 smoke particles from biomass burning (Vicente and Alves, 2018). Among aromatic compounds,
497 benzyl alcohol is worth mentioning because of the high concentrations. It is used as a solvent, and a
498 preservative. It is also employed in inks, textiles and sheet plastics, and as a fragrance in perfumes and
499 in flavouring.

500 Glycerol and many oxygenated derivatives were present at much higher concentrations in the
501 cafeteria compared to the outside. During the cooking process, triglycerides (i.e. fatty acids esterified
502 to a glycerol backbone) of fat in uncooked meat are hydrolysed or thermally oxidised, forming free
503 glycerol, free fatty acids and mono- and diglycerides (Abdullahi et al., 2013).

504 Cholesterol and phytosterols were abundant compounds in PM₁₀. Concentrations in the cafeteria
505 during the occupancy period far exceeded those recorded outdoors. Cholesterol (C₂₇) is biosynthesised
506 by higher animals and found in body tissues, especially in oils and fats. Phytosterols, such as β -
507 sitosterol and stigmasterol (C₂₉), are present in plant lipid waxes and membranes. All these sterols
508 were previously observed in PM_{2.5} emitted from Chinese cooking (He et al., 2004; Zhao et al, 2007).
509 However, cholesterol is the only sterol that have been detected in meat cooking fumes (Rogge et al.,
510 1991).

511 In the present study, many unusual compounds were detected in indoor aerosols, as far as we
512 know, for the first time. Some of the substances are part of the list of ingredients of various cosmetics.
513 Ethylene brassylate, for example, which was only present in indoor samples, is a macrocyclic
514 compound mainly used as a fragrance ingredient for its musk-like odour. Parsol MCX (ethylhexyl

515 methoxycinnamate) is used in the formulation of a wide variety of brands, including sunscreens and
516 makeup products that contain ingredients to protect the skin from the sun. A mean I/O ratio of 122
517 suggests its emission from personal care products and concentration build-up in confined spaces, such
518 as the cafeteria. Dibutyl adipate is the diester of butyl alcohol and adipic acid. In cosmetics and
519 personal care products, it is used in nail polish and skin care products. Once again, much higher
520 concentrations indoors than outdoors ($I/O=23$) indicate a possible origin in the products used by the
521 occupants. Because of its floral fragrance, methyl dihydrojasmonate is an additive in a wide range of
522 cleaning and personal care products. It was absent from outdoor samples, but the indoor
523 concentrations did not show appreciable differences between occupancy and non-occupancy periods,
524 suggesting the presence of a permanent source. Acetyl tributyl citrate is an organic compound that is
525 employed as a solvent in paints, inks, and nail enamel. It may also be found in eye makeup and
526 aerosol hair sprays. Moreover, it is used to make plastics more flexible (e.g. plasticisers in packaging
527 films for food), added as a flavour ingredient in non-alcoholic beverages and applied in the
528 manufacture of many pharmaceutical drugs. Acetyl tributyl citrate was only detected in indoor
529 aerosols. Pyroglutamic acid, known either as pyrrolidone-5-carboxylic acid, 5-oxoproline, PCA or
530 pidolic acid, is a ubiquitous natural amino acid derivative. It is used for dry skin and hair products,
531 owing to its humectant characteristics. Pidolic acid is found in large quantities in skin and brain
532 tissues. It is sold online as a nootropic dietary supplement to improve cognitive and executive
533 functions, and memory. The presence of this acid was only observed indoors, and at much higher
534 concentrations during the occupancy periods.

535 2-Propanol-1-chloro-phosphate, also known as Amgard TMCP or Hostaflam OP 820, is a chlorine
536 containing alkyl phosphate ester. It is mainly employed as an additive flame retardant, especially in
537 polyurethane foam, with some minor use in other plastics and as a back coating in textiles. It was only
538 present in indoor samples collected during daytime, including weekend. This suggests that the
539 emission of this compound can be promoted by sunlight, although its formation processes and
540 detection in the particulate phase deserve further investigation.

541 Another compound that was only detected indoors was piperonyl butoxide (PBO). It is a man-
542 made organic compound used as a component of pesticide formulations, particularly insecticides, and
543 classified as a synergist. By itself, PBO does not harm insects. Instead, it acts with insect killers to
544 intensify their effectiveness. Boric acid, which was present in both indoor and outdoor samples, is
545 also a pesticide that can be used to control a wide variety of pests, including insects, spiders, mites,
546 algae, moulds, fungi, and weeds.

547 Some psychoactive substances, including drugs of abuse (e.g. tetrahydrocannabinol, THC), were
548 found in the particulate matter samples. THC is the principal psychoactive constituent of cannabis.
549 THC was only present in two indoor samples collected during the occupancy periods, reaching 21.7
550 ng m^{-3} on Thursday, the day of the student party. THC was previously detected as a constituent of
551 outdoor airborne particles in 6 Spanish urban locations at concentrations ranging from 23 to 44 pg m^{-3}

552 (Viana et al., 2012). Another psychoactive substance in airborne particles was caffeine. However, this
 553 compound was only detected in outdoor samples and during non-occupancy periods. Since caffeine is
 554 expected to partition between the gas and the particulate matter (Viana et al., 2012), its absence during
 555 working hours may be related to the higher temperatures in the cafeteria because of the use of heating.
 556 In the outdoor air across Italy, caffeine reached gross average concentrations of 15 ± 8 ng m⁻³ in winter
 557 and 1.2 ± 0.6 ng m⁻³ in summer, while in the metropolitan area of Rome the corresponding levels were
 558 1.5 ± 0.5 ng m⁻³ and 0.3 ± 0.1 ng m⁻³ (Viana et al., 2012; and references therein).

559 Nicotinic acid, also denominated niacin or vitamin B3, is present in all living cells and found in
 560 whole and processed foods. It is used to make other chemicals and added to feeds and flours as a
 561 dietary supplement. It is also used as a medication to treat dyslipidaemic states. Niacin was not
 562 detected in outdoor air but reached concentrations up to 16.1 ng m⁻³ in the cafeteria during the
 563 occupancy period. The mechanisms by which it is formed and remains airborne in the particulate
 564 phase are yet to be clarified.

565 Irgafos 168 (tris(2,4-di-tert-butylphenyl)phosphite), as one of the common antioxidants, is
 566 extensively used in polyolefin materials (e.g. polypropylene employed in food packaging), to protect
 567 polymers from aging and oxidation. However, irgafos 168 may degrade into several products, such as
 568 2,4-di-tert-butylphenol (DP1), and tris(2,4-di-tert-butylphenyl)phosphate (DP2), which is the
 569 oxidised form of irgafos 168 (Yan et al., 2018). In the present study, whilst DP1 was detected at 5-
 570 fold higher concentrations in the cafeteria than outside, DP2 was only present in two daytime indoor
 571 samples (both with 19 ng m⁻³) and in just one outdoor sample (39 ng m⁻³).

573 3.2.3. Health risk analysis

574
 575 Noncarcinogenic and carcinogenic risks associated with inhalation exposure to trace elements in
 576 indoor PM₁₀ by the employees were estimated following the methodology proposed by the United
 577 States Environmental Protection Agency (USEPA, 1989, 2009):

$$578 \text{THQ} = (\text{EF} \times \text{ED} \times \text{ET} \times \text{C}) / (\text{RfC} \times \text{AT}) \quad (6)$$

$$580 \text{TR} = (\text{EF} \times \text{ED} \times \text{ET} \times \text{C} \times \text{IUR}) / \text{AT} \quad (7)$$

581
 582 The target hazard quotient (THQ) and target carcinogenic risk (TR) are dimensionless, EF is the
 583 occupational exposure frequency (250 days per year, i.e. 5 days per 50 weeks), ED is the exposure
 584 duration (25 years), ET is the exposure time (8 h per day), C is the metal concentration in the air (mg
 585 m⁻³), and AT is the averaging time (365 days per year \times 24 h per day \times ED for noncarcinogenic
 586 effects and 612,000 h, i.e., 70 years \times 365 days per year \times 24 h per day, for carcinogenic effects). RfC
 587 is the USEPA reference concentration (mg m⁻³). Considering that for some elements, reference doses

588 for oral exposure (RfD, mg kg⁻¹ day⁻¹) are available instead of RfC values (USEPA, 2017, 2019),
 589 these latter were derived using the following equation (USEPA, 2013):

590

$$591 \text{ RfC} = (\text{RfD} \times \text{BW}) / \text{IR} \quad (8)$$

592

593 where IR and BW are the inhalation rate and body weight of an adult (20 m³ day⁻¹ and 70 kg).
 594 Chronic inhalation unit risk (IUR) values for the carcinogenic elements found in the PM₁₀ samples
 595 were taken from USEPA (2017): arsenic 4.3×10⁻³ (μg m⁻³)⁻¹, lead 1.2×10⁻⁵ (μg m⁻³)⁻¹, hexavalent
 596 chromium 8.4×10⁻² (μg m⁻³)⁻¹ and Ni oxide 2.6 × 10⁻⁵ (μg m⁻³)⁻¹. The IUR of Cr(VI) is based on a
 597 Cr(III):Cr(VI) proportion of 1/6. Since in the present study total Cr was determined, one seventh of
 598 the concentration obtained was used to estimate the risk.

599 The noncarcinogenic risks associated with inhalation exposure by employees to particulate trace
 600 elements in the indoor air during the occupancy period are presented in Figure 8. A THQ < 1 indicates
 601 no significant (acceptable) risk, a THQ > 1 suggests that the noncarcinogenic effect is likely to
 602 manifest, whereas a high chronic risk is evident when THQ > 10 (Slezakova et al., 2014). The
 603 estimated mean THQ for PM₁₀-bound trace elements ranged from null values for many elements 0.92
 604 for Cl. The total mean THQ of all eleven elements in PM₁₀ was 1.7. Cl and Mn were the most
 605 important contributors (55 and 38 %, respectively) to the total noncarcinogenic risk, followed by Si
 606 (6.0 %), and Al (1.3 %). If the exposure time and frequency assumed for the working hours were
 607 considered for non-occupancy periods and for outdoor air, ΣTHQ values of 0.17-0.26 and around 2.0
 608 would be obtained, respectively.

609 For carcinogenic constituents, USEPA considers that targeting a 10⁻⁶ risk level for individual
 610 chemicals and pathways will usually lead to negligible risks. However, caution is suggested to
 611 guarantee that the cumulative cancer risk for all potential carcinogenic contaminants does not have a
 612 residual cancer risk above 10⁻⁴ (Slezakova et al., 2014). In the present study, ΣTR was always < 2×10⁻⁶,
 613 suggesting that the risk associated with the exposure to PM₁₀-bound carcinogenic elements is
 614 negligible.

615 To estimate the carcinogenic risks associated with PAH inhalation, the benzo[a]pyrene equivalent
 616 carcinogenicity (BaP_{eq}) was evaluated by multiplying concentration of each PAH with their toxicity
 617 equivalent factor (TEF) (Bari et al., 2010, and references therein). The exposure concentration (EC) is
 618 calculated as follows (CalEPA, 2005):

619

$$620 \text{ EC} = (\text{CA} \times \text{ET} \times \text{EF} \times \text{ED}) / \text{AT} \quad (9)$$

621

622 where CA represent the benzo[a]pyrene equivalent concentrations (ng m⁻³). The inhalation unit risk
 623 (IUR) of respiratory cancer for BaP_{eq} is 3.9 × 10⁻⁶ (ng kg day)⁻¹. This value is obtained multiplying the

624 inhalation cancer risk unit factor of BaP (1.1×10^{-6} (ng kg day)⁻¹) by the inhalation rate (20 m³ per
625 day) and dividing by the body weight (70 kg). The carcinogenic risk of the PAH mixture is then
626 calculated using the following equation:

627

$$628 \text{ Risk} = \text{IUR} \times \text{EC} \quad (10)$$

629

630 The mean estimated excess inhalation cancer risk associated with total BaP_{eq} concentrations in the
631 cafeteria during the occupancy periods was 3×10^{-8} , which is considered negligible. Outdoor and non-
632 occupancy PAH levels also pose insignificant risks. However, it should be noted that other routes of
633 exposure (dermal and ingestion) have not been considered and that only particle-bound PAH were
634 used in the estimates. After formation and emission, these compounds partition between the gas phase
635 and atmospheric aerosols.

636

637 **4. Conclusions**

638

639 A short, but comprehensive, air quality monitoring programme was carried out in a university
640 cafeteria, a type of occupational environment for which no inspections have been made so far. The
641 mean values obtained for comfort parameters and regulated pollutants were, generally, within the
642 ranges stipulated by international organisations. However, real time measurements of CO₂ and
643 particulate matter revealed strong fluctuations, depending on activities and occupancy rates. Very low
644 air change rates and particle infiltration factors from outdoors indicate inadequate ventilation. For
645 most pollutants, the indoor levels during the working hours largely exceeded those measured at night
646 and outdoors, pointing to the presence of multiple indoor sources. It was observed that more than 80
647 % of the particle mass concentrations were generated indoors. Several metals, either crustal or
648 anthropogenic, were detected in the particulate matter. About 200 organic compounds were also
649 identified, some of which, to the best of our knowledge, are described as indoor aerosol constituents
650 for the first time. Many organic compounds detected in indoor air are components of various
651 cosmetics and other personal care products, but also of pesticides, drugs of abuse, plastics, building
652 materials (e.g. flame retardants), cooking emissions, sweat, among others. Some compounds can also
653 be secondarily formed as by-products of surface reactions. However, the formation pathways of many
654 compounds and the partitioning mechanisms between the gas and the particulate phases of some semi-
655 volatiles are complex and still far from being well elucidated, deserving extensive investigation in the
656 future.

657 The total mean hazard quotient that represents the noncarcinogenic effects due to the inhalation of
658 particle-bound metals during the occupancy period in the cafeteria was higher than the acceptable
659 level (>1). The cumulative cancer risk for both carcinogenic metals and PAHs was lower than the

660 acceptable level (10^{-4}). However, exposure to metals and PAHs occurs also via ingestion and dermal
661 contact and if these routes are considered, then the estimated risks might be higher.

662 To protect the restaurant workers and other public, possible strategies to control and minimise the
663 emissions of indoor pollutants at their point sources within the cafeteria, such as confining the
664 cooking area and equipping the kitchen with a more efficient smoke exhaust system, should be
665 targeted. Other measures could be the installation of appropriate ventilation and air cleaner systems in
666 the dining room, the use of eco-labelled cleaning products, the adoption of integrated pest
667 management (IPM) alternatives to pesticides, placing footwear sanitiser mats at the entrance,
668 inspection of wall coverings and other building materials and, if necessary, replacement by low
669 emitting materials, minimising the use of plastics and compliance with prohibitions (e.g. smoking). At
670 the official level, the implementation of regular inspection protocols is also essential.

671

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673

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Table 1Weekly concentrations of volatile organic compounds ($\mu\text{g m}^{-3}$) monitored by passive sampling

	n-hexane	1-butanol	benzene	toluene	ethyl benzene	m-xylene	p-xylene	2-ethoxyethyl acetate	o-xylene	1,2,4-trimethylbenzene
Indoor	0.4-1.1	3.7-13.8	0.9-1.4	3.4-10.4	0.7-1.0	1.8-2.4	0.7-1.4	<0.3	0.8-1.1	0.8-1.2
Outdoor	0.1	<2.0	0.6-0.8	1.3-1.6	0.3-0.5	0.6-1.0	0.3-0.4	<0.3	0.3-0.5	0.4-0.5
I/O	3.8-12.6	-	1.3-1.8	2.1-6.2	1.5-3.1	1.9-3.2	1.5-3.1	-	1.4-2.9	1.7-3.0

Table 2Minimum, maximum and average concentrations of elements (ng m^{-3}), enrichment factors and indoor/outdoor ratios for working hours

		Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	As	Se	Br	Rb	Sr	Y	Zr	Mo	Pb		
Indoor	Occupancy	Day	Min	197	69.0	173	347	20.5	100	214	305	452	11.1	-	0.418	3.93	93.4	0.356	2.73	10.3	-	-	1.24	0.426	1.26	-	0.900	-	0.603
			Max	356	776	1151	828	390	1070	1870	2140	850	33.9	0.682	5.47	8.72	271	3.91	14.9	60.9	1.41	3.89	4.31	1.25	4.94	0.304	2.03	2.05	5.98
			Avg	250	232	465	620	27.3	485	607	692	625	22.3	0.190	1.66	5.54	195	1.49	6.90	27.8	0.757	1.62	2.77	0.749	3.00	0.089	1.27	0.551	2.80
			EF	1.6	2.4	0.88	0.33	7.0	86	137	3.0	3.5	1.1	0.67	6.8	1.7	-	12	73	80	59	3094	284	1.1	1.5	0.64	0.89	68	26
Indoor	Night	Min	41.5	9.58	30.5	58.1	0.158	155	13.3	117	8.37	2.43	0.695	-	-	26.7	-	0.98	7.01	0.102	0.427	0.450	-	-	-	-	-	-	
		Max	115	23.9	100	137	3.11	500	79.8	197	51.2	4.20	0.947	0.421	1.44	53.6	0.496	1.23	10.6	1.06	1.96	0.628	0.856	1.02	-	0.424	2.61	5.46	
		Avg	73.2	14.8	71.8	110	1.49	305	37.8	148	28.6	3.19	0.790	0.215	0.766	39.7	0.277	1.09	8.27	0.532	1.15	0.566	0.285	0.627	-	0.141	0.944	2.51	
		EF	2.3	0.86	0.74	0.29	1.7	220	47.1	3.2	0.79	0.78	11	5.1	1.2	-	13	56	115	217	9397	260	1.5	1.4	-	0.34	541	95	
Outdoor	Day	Min	403	79.3	142	243	5.32	152	470	60.6	123	6.25	0.239	-	2.17	136	-	2.36	6.16	-	0.011	1.77	0.334	1.18	-	0.507	-	0.189	
		Max	766	130	619	1363	26.3	1711	988	365	641	31.5	2.76	2.55	10.6	660	1.00	14.8	32.9	2.76	9.69	9.24	2.57	5.31	1.62	3.35	6.35	6.04	
		Avg	550	102	424	802	15.3	570	722	184	356	20.7	1.23	1.11	6.09	397	0.459	8.15	17.0	0.958	2.61	3.75	1.30	3.66	0.800	1.69	2.03	2.86	
		EF	2.3	0.75	0.44	0.20	1.8	32	106	0.39	0.91	0.52	1.7	1.7	0.90	-	1.5	42	24	23	1105	161	1.0	0.94	4.3	0.61	150	10	
Indoor	Non-oc.	Day	Concent.	224	24.7	41.0	72.6	5.45	182	114	35.5	21.0	2.43	-	-	0.621	25.7	0.450	0.867	1.13	0.585	0.924	0.819	-	-	-	-	1.72	-
			EF	11	2.2	0.64	0.29	9.8	230	214	1.3	0.86	0.93	-	-	1.4	-	29	73	26	351	13370	615	-	-	-	-	1474	-
I/O		0.46	2.3	1.1	0.77	1.8	0.85	0.84	3.8	1.8	1.1	0.16	1.5	0.91	0.49	3.3	0.85	1.6	0.79	-	0.74	0.57	0.82	0.11	0.75	-	0.98		

Table 3Concentrations (ng m⁻³) of oxygenated organic compounds in PM₁₀

	Indoor occupancy	Indoor non-occupancy (night-time)	Indoor non-occupancy (Sunday, daytime)	Outdoor daytime	I/O (occupancy)
<i>Saccharides</i>					
Galactosan	1.60±0.61	2.05	0.422	4.5±4.0	0.4
Mannosan	3.72±2.12	4.49	0.904	8.4±6.2	0.4
Levogluconan	39.5±11.4	41.9	bdl	59±55	0.7
Unidentified saccharides	90.6±46.6	0.84	2.00	10.6±4.9	8.5
<i>Phenolics and alteration products</i>					
Pyrocatechol	0.006±0.002	0.004	bdl	0.005±0.004	1.0
Resorcinol	0.019±0.012	0.073	0.003	0.10±0.12	0.2
4-Methylcatechol	0.004±0.002	0.004	bdl	0.003±0.003	1.1
5-Isopropyl-3-methylphenol	0.065±0.051	bdl	bdl	0.029±0.027	2.2
2-Isopropyl-5-methylphenol (thymol)	0.64±0.36	0.070	0.242	0.34±0.38	1.9
Eugenol	0.004±0.003	0.002	0.001	0.001±0.001	5.4
2,4-Di-tert-butylphenol	26.4±19.8	bdl	4.03	5.4±4.7	4.9
4-tert-Butylphenol + unknown	13.0±7.3	10.0	bdl	9±11	1.4
Pyrogallol	0.004±0.004	0.004	0.001	0.005±0.003	0.8
Isoeugenol	0.51±0.37	bdl	0.134	0.25±0.18	2.1
2-Methoxy-4-propylphenol	0.002±0.001	0.005	bdl	0.003±0.003	0.5
4-Phenylphenol	0.030±0.028	0.037	bdl	0.038±0.031	0.8
4-Octylphenol	0.011±0.007	0.002	bdl	0.006±0.004	1.8

Benzyl alcohol	10.0±4.5	0.050	3.24	18.0±20	0.6
Benzoic acid	0.38±0.43	0.063	bdl	0.024±0.029	15
3-Hydroxybenzoic acid	1.53±0.41	bdl	bdl	0.63±0.30	2.4
4-Hydroxybenzoic acid	0.65±0.23	0.587	0.097	0.82±0.67	0.8
Vanillic acid	0.35±0.23	0.172	0.118	0.56±0.36	0.6
Sinapyl alcohol	0.053±0.066	0.141	bdl	0.005±0.008	9.7
Syringic acid	0.20±0.22	0.452	0.073	0.24±0.25	0.8
trans-Cinnamic acid	0.22±0.23	bdl	0.071	0.080±0.065	2.8
4-Hydroxy-3-methoxycinnamic (ferulic) acid	0.032±0.028	0.004	bdl	0.013±0.009	2.4
3,4-Dihydroxycinnamic (caffeic) acid	0.013±0.017	bdl	bdl	0.001±0.001	9.0
4-Hydroxycinnamic (p-coumaric) acid	0.49±0.56	bdl	bdl	0.14±0.13	3.5
<i>Aliphatic alcohols</i>					
1-Decanol	0.043±0.038	0.001	0.004	0.005±0.007	9.3
1-Pentadecanol	11.8±7.6	8.63	13.2	bdl	-
iso- or anteiso-Pentadecanol	1.42±0.73	bdl	1.98	0.26±0.14	5.5
1-Hexadecanol	38.6±18.4	bld	72.2	0.06±0.13	681
2-Hexadecanol	4.8±2.1	1.60	bld	bdl	-
Iso- or anteiso-heptadecanol	0.56±0.64	bdl	0.860	bdl	-
1-Heptadecanol	2.2±2.0	1.62	bdl	bdl	-
1-Octadecanol	45±14	13.7	5.36	0.07±0.16	643
1-Eicosanol	2.05±0.80	1.27	0.399	1.2±1.1	1.7
1-Docosanol	2.25±0.87	2.14	0.320	2.0±1.3	1.2
1-Tricosanol	0.225±0.060	0.220	0.025	0.10±0.12	2.3
1-Tetracosanol	1.10±0.36	1.59	bdl	1.58±0.72	0.7

1-Pentacosanol	0.26±0.13	0.189	0.014	0.17±0.12	1.6
1-Hexacosanol	6.0±9.1	3.33	0.341	5.7±4.6	1.1
1-Heptacosanol	0.121±0.057	0.076	0.005	0.07±0.10	1.7
1-Octacosanol	1.5±0.21	1.76	0.240	2.4±3.3	0.6
1-Triacontanol	0.248±0.091	0.229	0.010	0.36±0.65	0.7
<i>Triterpenoid and steroid compounds</i>					
Tocopherol (Vit. E)	0.19±0.12	0.006	bdl	0.010±0.009	19
Cholesterol	20.0±8.5	0.170	0.019	0.14±0.15	139
5-Cholesten-3-ol (epicholesterol)	0.27±0.14	bdl	bdl	0.049±0.089	5.6
Stigmasterol	7.7±2.5	0.314	bdl	0.45±0.56	17
β-Sitosterol	5.7±2.1	1.37	0.008	0.8±1.4	7.0
Lupeol	0.204±0.072	1.11	0.123	0.42±0.44	1.0
<i>Aliphatic acids</i>					
Hexanoic	1.07±0.44	0.053	bdl	0.43±0.35	2.5
Heptanoic	4.8±3.6	0.073	0.059	0.37±0.33	13
Octanoic	2.4±1.9	0.370	0.142	0.46±0.40	5.3
Decanoic	2.7±3.0	bdl	0.106	0.37±0.31	7.4
Undecanoic	0.20±0.29	bdl	0.081	bdl	-
Nonanoic	37±37	1.13	1.35	2.4±2.1	15
Dodecanoic	9±13	1.97	0.051	3.1±5.7	3.0
Tridecanoic	2.9±2.8	1.12	3.03	bdl	-
Isotridecanoic	3.2±2.3	3.00	4.21	bdl	-
Tetradecanoic (myristic)	72±28	30.3	66.2	1.0±1.3	73
Pentadecanoic	15.7±4.6	0.286	7.29	0.06±0.11	266

Isotetradecanoic	13.4±6.5	3.780	10.9	bdl	-
Hexadecanoic (palmitic)	117±69	bdl	bdl	10.6±9.9	11
Iso-hexadecanoic	4.5±2.6	0.143	2.06	bdl	-
5-Hexadecenoic	3.10±0.86	bdl	1.13	bdl	-
9-Hexadecenoic (palmitoleic)	1.43±0.85	0.0524	0.106	0.080±0.099	18
Heptadecanoic	14.8±8.2	bdl	0.523	0.38±0.34	39
Isoheptadecanoic	7.6±2.6	0.095	1.55	bdl	-
Octadecanoic (stearic)	116±62	bdl	bdl	1.9±2.6	61
9-Octadecenoic (oleic)	103±35	1.99	0.219	1.1±1.1	93
9,12-Octadecadienoic (linoleic)	30±14	0.272	0.017	0.47±0.74	64
9,12,15-Octadecatrienoic (linolenic)	17±25	bdl	bdl	0.35±0.77	49
Nonadecanoic	0.99±0.30	0.022	0.053	0.140±0.082	6.5
Eicosanoic	8.0±2.9	0.618	0.200	2.2±2.0	3.7
Heneicosanoic	bdl	bdl	0.221	0.22±0.23	-
Docosanoic	9.0±3.2	2.46	0.171	2.2±2.1	4.1
Pentacosanoic	2.0±1.7	bdl	bdl	0.10±0.23	20
Hexacosanoic	1.36±0.66	0.509	0.046	0.54±0.57	2.5
<i>Diacids</i>					
Butanedioic (succinic)	2.8±2.4	bdl	0.691	2.3±1.4	1.2
1,5-Pentanedioic (glutaric)	3.9±2.6	1.52	5.25	0.07±0.14	58
Hydroxybutanedioic (malic)	0.7±1.0	bdl	bdl	0.5±1.2	1.2
Hexanedioic (adipic)	1.07±0.31	bdl	0.388	bdl	-
Heptanedioic (pimelic)	1.28±0.25	0.032	0.190	0.116±0.076	11
Octanedioic (suberic)	3.0±1.1	bdl	0.338	0.175±0.098	17

Nonanedioic (azelaic)	44±21	1.08	1.09	7.0±4.0	6.2
Decanedioic (sebacic)	0.111±0.031	bdl	bld	0.010±0.010	12
Hexanedecanoic (thapsic)	0.052±0.022	bdl	0.006	0.023±0.031	2.2
<i>Resin acids</i>					
Dehydroabietic	3.0±1.4	1.98	0.757	4.6±1.7	0.6
Isopimaric	0.14±0.31	0.130	0.057	0.12±0.16	1.1
Abietic	0.119±0.061	0.054	bdl	0.076±0.088	1.6
Podocarpic	0.038±0.027	bdl	bdl	0.001±0.002	1.1
<i>Other acids</i>					
Boric	15±15	2.42	11.8	13±12	1.1
Propionic (lactic)	130±120	bdl	35.9	bdl	-
4-Oxopentanoic (levulinic)	13.2±9.6	5.31	1.26	0.64±0.88	15
2-Hydroxyethanoic (glycolic)	32±42	bdl	6.45	5.3±8.6	6.0
2,3-Dihydroxypropanoic (glyceric)	9.4±7.0	bdl	1.41	1.0±1.1	9.7
3-Hydroxybutanoic (3-hydroxybutyric)	0.23±0.35	bdl	0.152	0.049±0.079	4.7
3,4-Dihydroxybutanoic	3.1±2.0	bdl	0.691	0.98±0.61	3.2
Nicotinic	8.6±5.3	4.67	6.84	bdl	-
cis-Pinonic	1.03±0.87	bdl	1.05	0.53±0.45	1.9
Pinic	1.10±0.80	0.933	0.424	1.5±1.4	0.7
2-Hydroxypropane-1,2,3-tricarboxylic (citric)	1.0±1.1	bdl	0.912	0.30±0.28	3.4
<i>Glycerol derivatives</i>					
Glycerol	80±35	17.7	57.2	32±30	2.5
Diethylene glycol	12.2±7.0	4.22	10.8	6.8±2.7	1.8
1-Monolauroyl-rac-glycerol	0.021±0.014	bdl	bdl	0.001±0.000	23

1-Glycerol monostearate (1-monostearin)	170±130	1.29	7.52	4.0±3.3	42
2-Glycerol monostearate (2-monostearin)	16±15	bdl	bdl	0.030±0.042	550
Heptadecanoic acid glycerin-(1)-monoester	6.0±4.9	bdl	bdl	bdl	-
1-Monolinoleoylglycerol	23±18	bdl	bdl	bdl	-
1-Monopalmitin	190±110	0.519	0.902	4.3±2.7	45
1-Monomyristin	33±22	0.776	0.616	1.350±0.066	25
<i>Other compounds</i>					
Myrtenol	0.005±0.005	bdl	bdl	-	-
Hydroquinone	0.142±0.022	0.112	bdl	0.15±0.12	0.9
Hydroxyacetophenone	0.19±0.17	0.382	bdl	1.40±0.91	0.1
2,6-Di-tert-butyl-1,4-benzoquinone	0.44±0.40	bdl	0.088	0.36±0.21	1.2
Methyl dihydrojasmonate	46±29	55.1	55.9	-	-
2-Propanol-1-chloro-phosphate (TCPP)	1.6±1.2	bdl	4.24	-	-
Ethylene brassylate	18.4±6.2	6.77	6.24	-	-
5-oxo-L-proline	19±14	bdl	1.24	-	-
Caffeine	-	6.31	9.85	1.4±3.0	-
Parsol MCX	12.6±6.6	2.93	11.2	0.10±0.14	122
Acetyl tributyl citrate	4.0±1.6	1.78	2.82	-	-
Diisooctyl adipate	10.0±3.5	2.55	5.40	2.7±5.9	3.8
Dibutyl adipate	14.2±7.4	6.33	4.82	0.6±1.3	23
Δ-1-Tetrahydrocannabinol	4.8±9.5	bdl	bdl	-	-
Piperonyl butoxide	9.3±3.7	4.25	6.68	-	-
Oxidised Irgafos 168	7±10	bdl	bdl	8±18	1.0
<i>Plasticisers</i>					

Dimethyl phthalate	bld	0.002	bdl	bdl	-
Diethyl phthalate	0.064±0.092	bdl	bdl	0.24±0.27	0.26
Di-n-butyl phthalate	0.23±0.21	0.059	bdl	2.1±2.6	0.11
Benzyl butyl phthalate	0.004±0.008	bdl	bdl	0.05±0.10	0.08
Bis(2-ethylhexyl) adipate	0.006±0.009	bdl	bdl	0.09±0.19	0.06
Bis(2-ethylhexyl) phthalate	0.17±0.23	bdl	bdl	2.1±4.4	0.08
Unidentified phthalate	280±160	121	163	19±25	15

bld – below detection limit

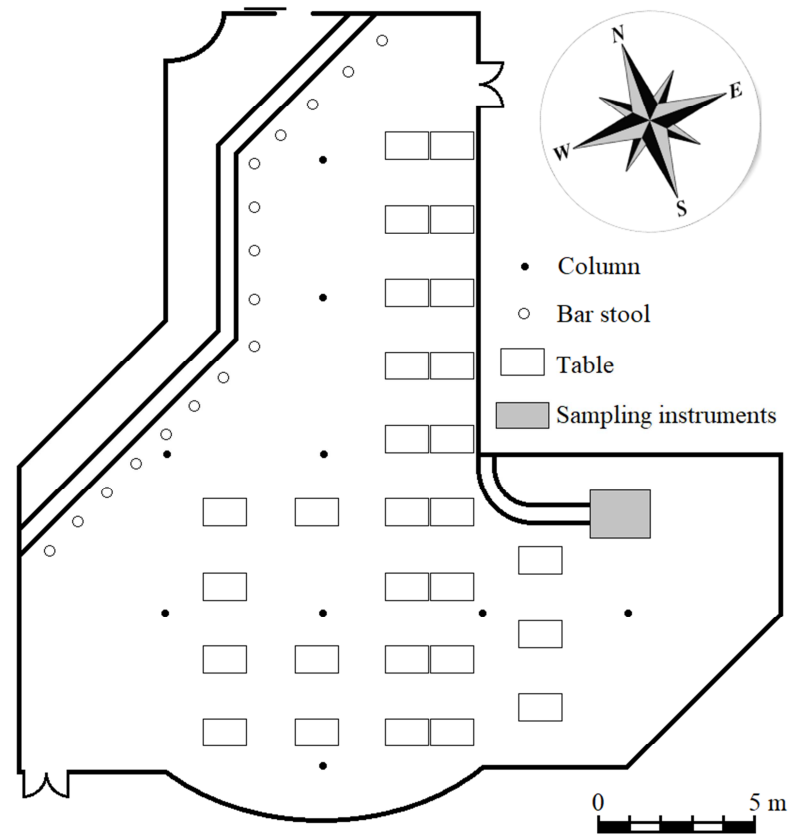


Fig 1. Floor plan of the cafeteria. Each table has four chairs.

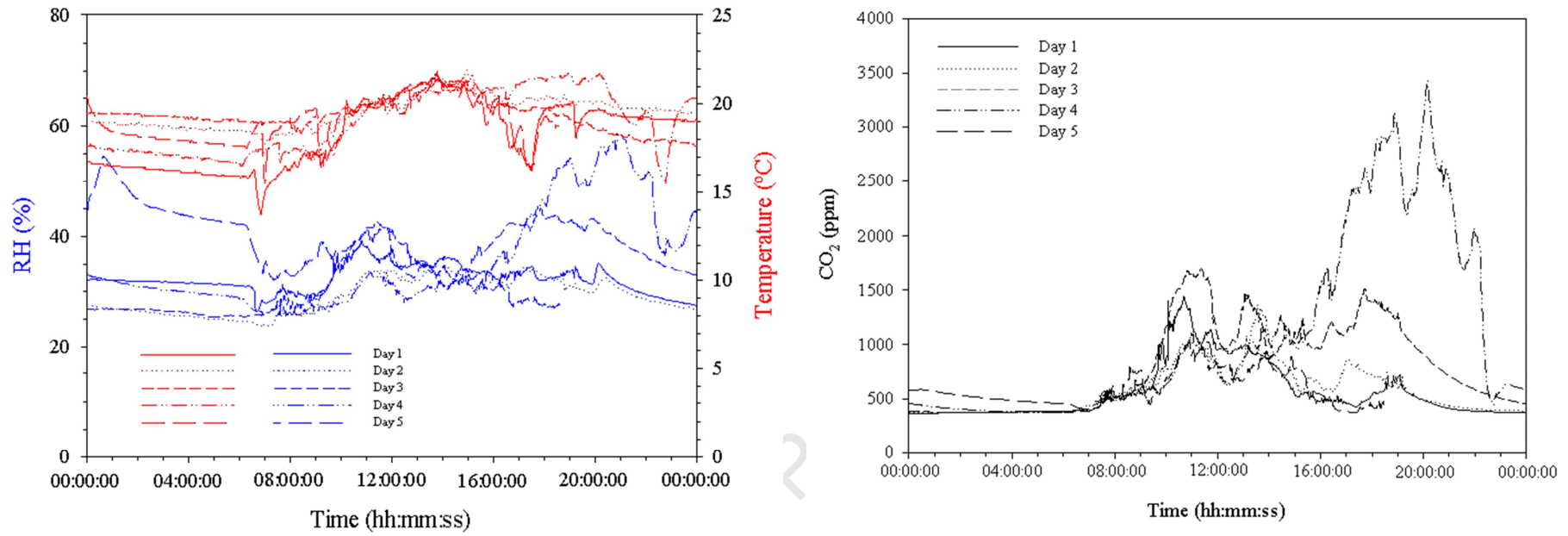


Fig 2. Variation of relative humidity, temperature and carbon dioxide levels on weekdays.

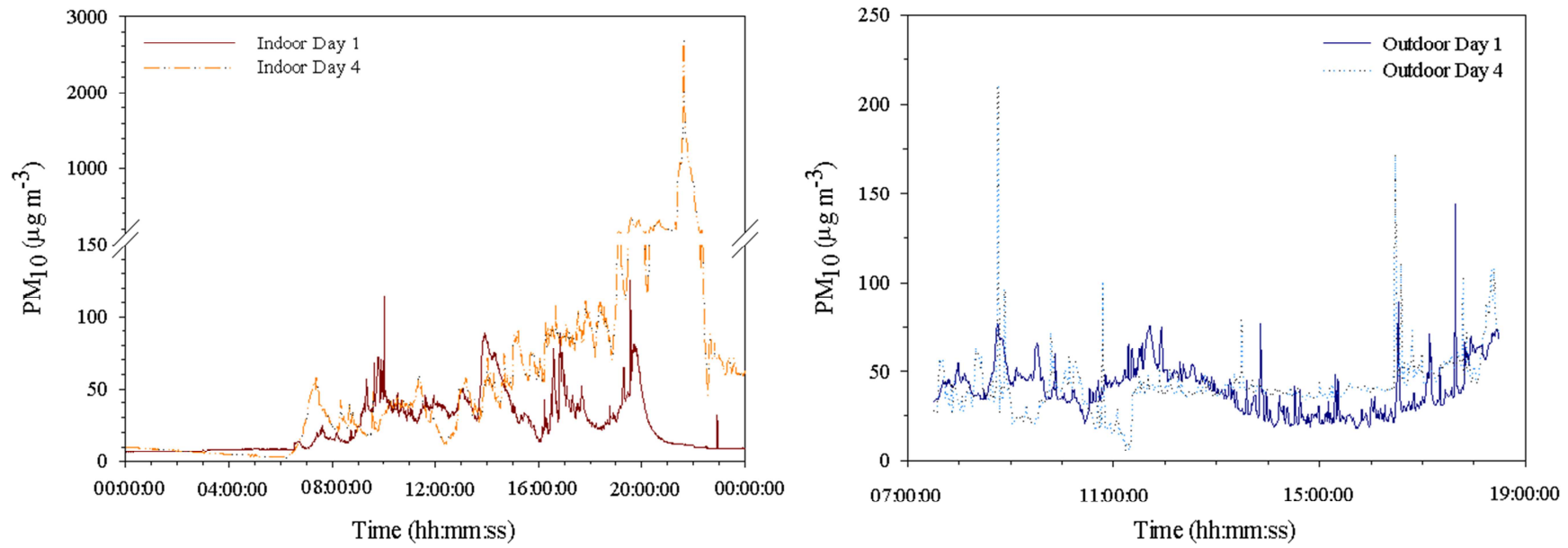


Fig. 3. Examples of PM₁₀ daily concentration profiles in the cafeteria and outdoors (Day 1 – Monday, Day 4 – Thursday).

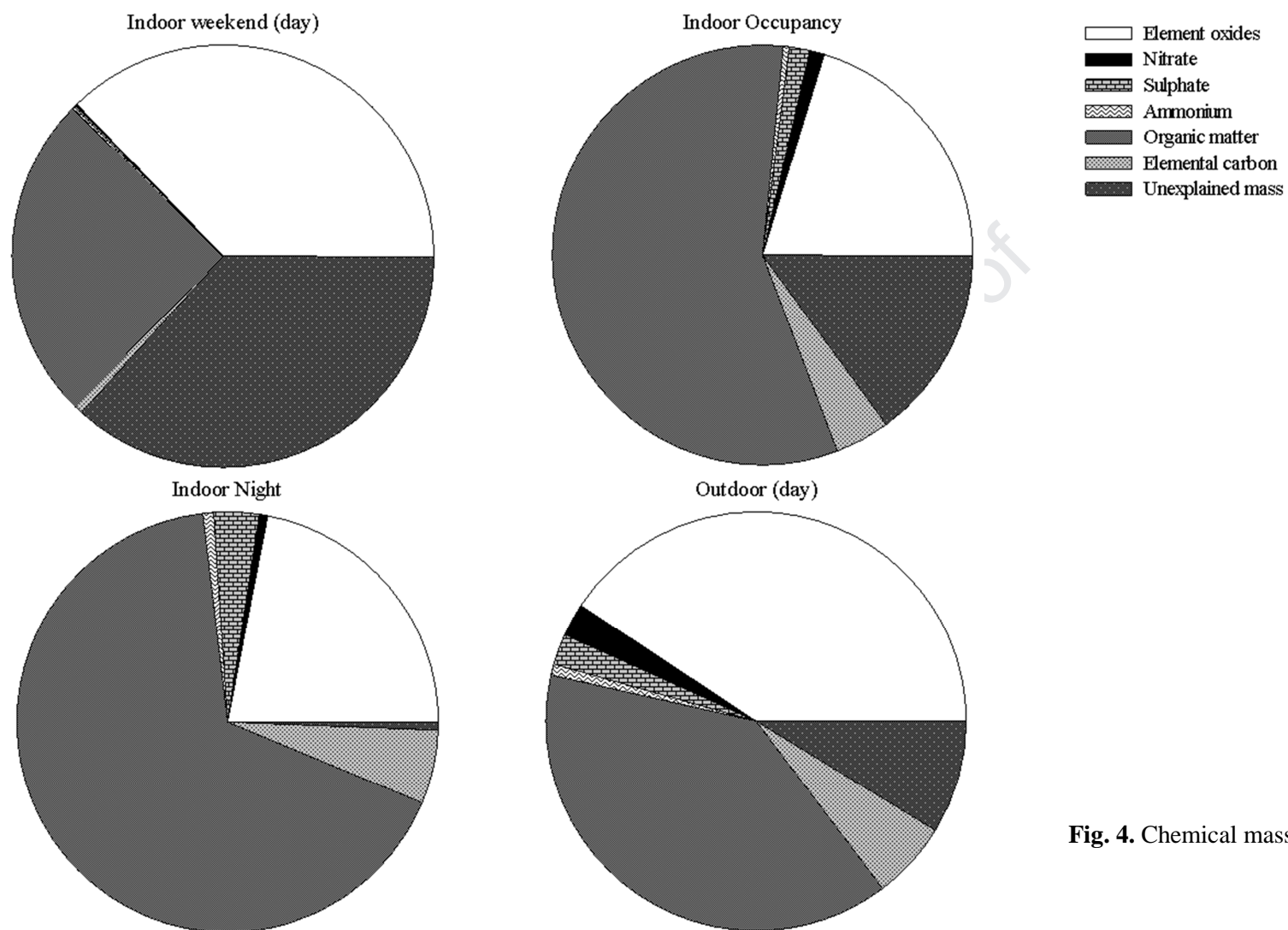


Fig. 4. Chemical mass closure of PM₁₀.

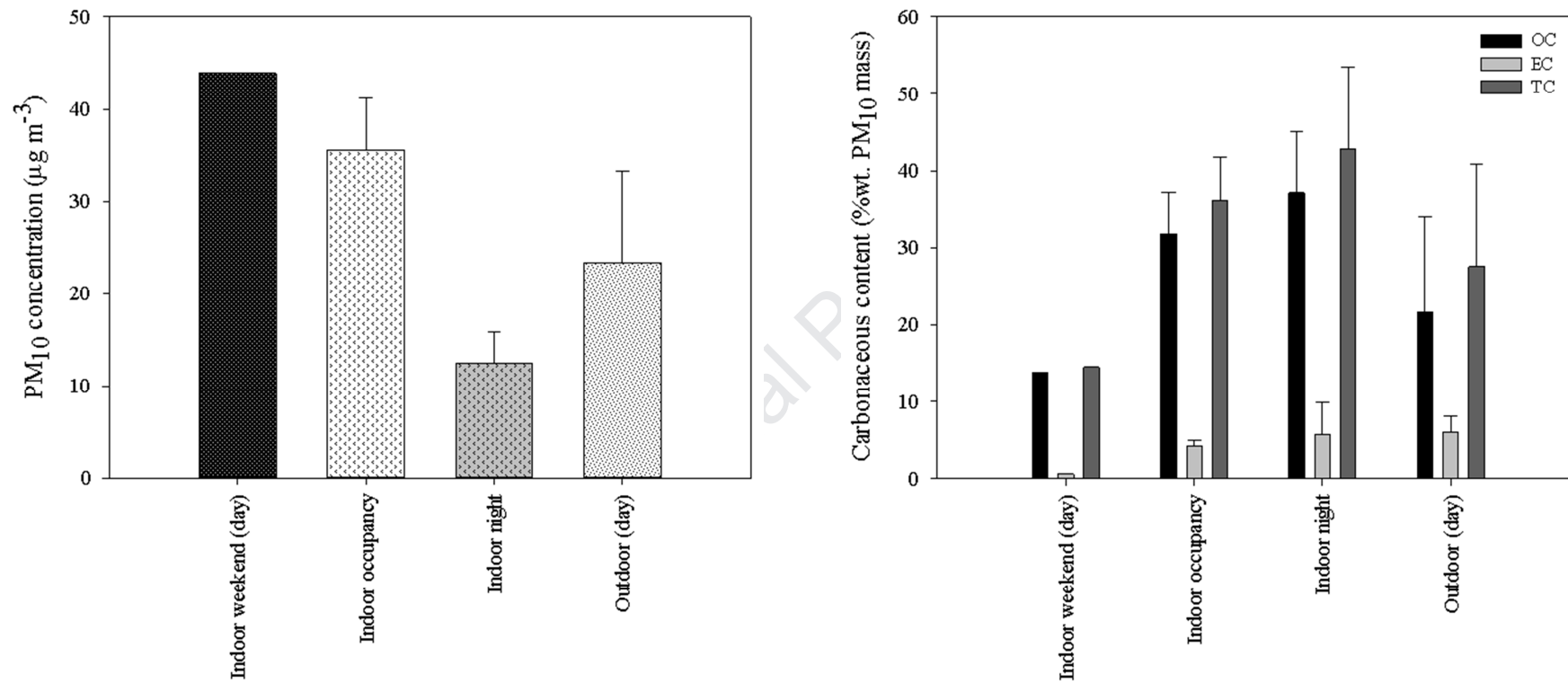


Fig 5. Means (\pm SD) of PM₁₀ concentrations and mass fractions of organic carbon, elemental carbon and total carbon (TC = OC + EC)

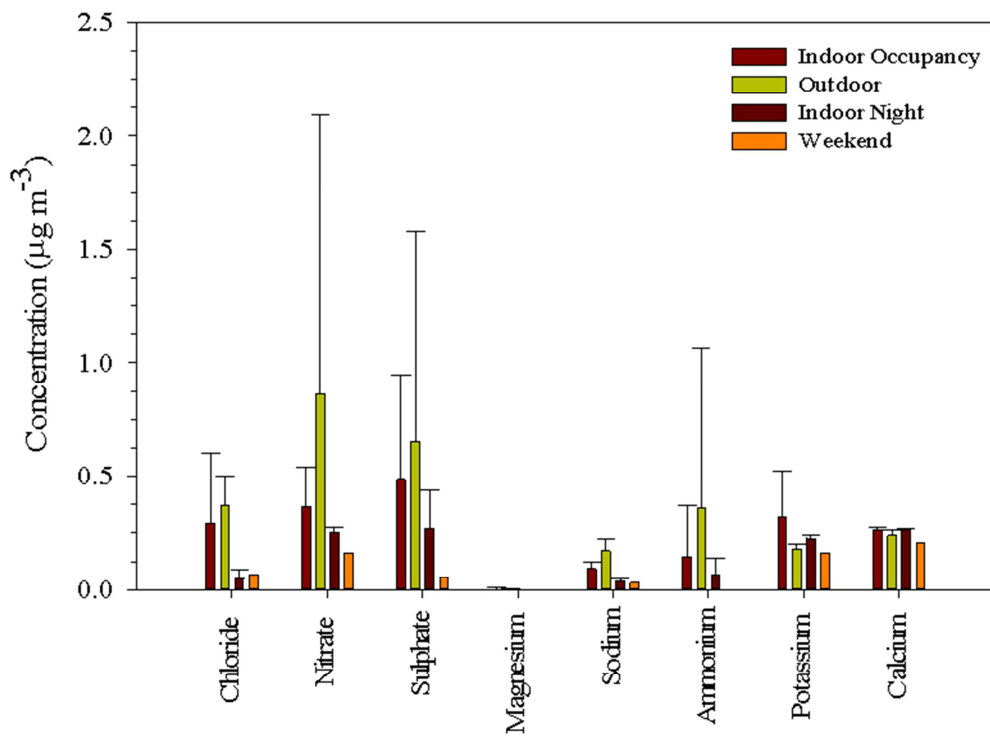


Fig. 6. Concentrations (mean±SD) of water-soluble ions in PM₁₀ collected indoors and outdoors.

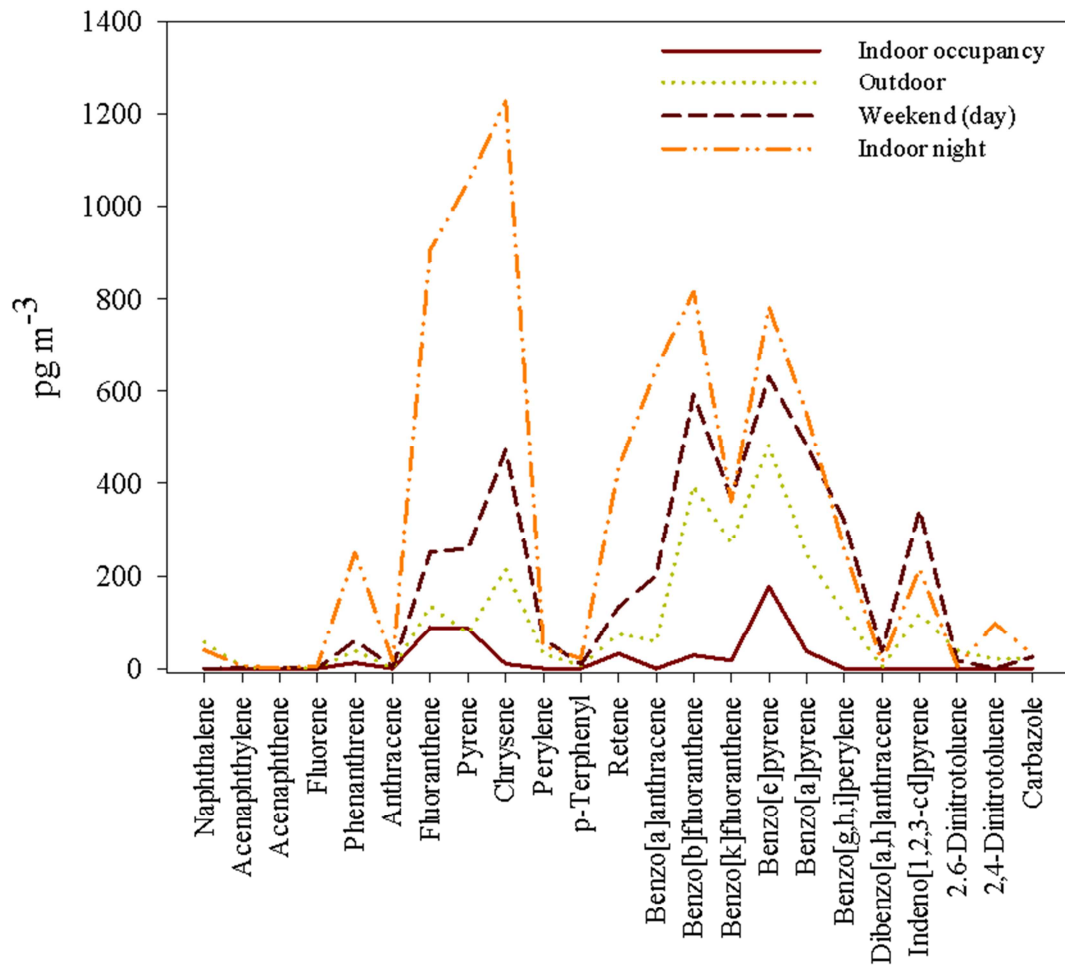


Fig. 7. Average concentrations of polycyclic aromatic hydrocarbons.

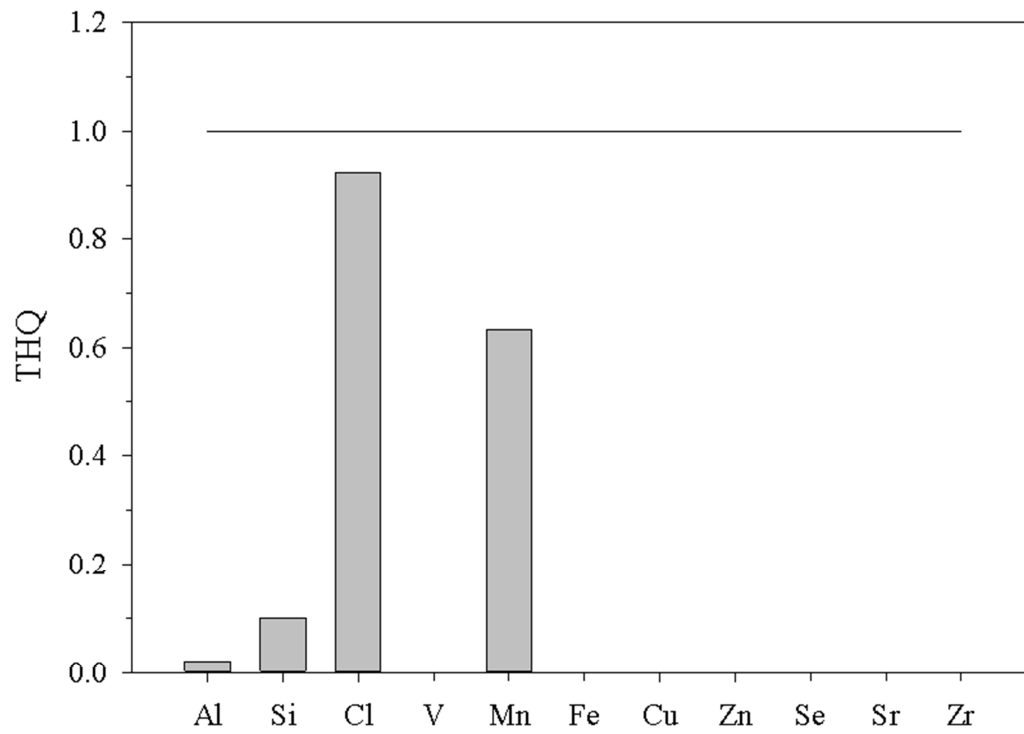


Fig. 8. Mean risks from inhalation exposure to noncarcinogenic PM₁₀-bound metals for the cafeteria workers during the occupancy period. The horizontal line represents the USEPA health-based guideline level.

HIGHLIGHTS

Indoor air quality in a cafeteria revealed poor ventilation conditions

Concentrations of most pollutants were much higher indoors than outdoors

More than 80% of the particles were generated indoors

PM₁₀ included components of personal care products, plasticisers and psychoactive drugs

Cancer risk associated with inhalation of metals and PAHs was found to be negligible

Journal Pre-proof

Conflicts of Interest: The authors declare no conflict of interest.

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