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# Toward an interdisciplinary approach to assess the adverse health effects of dust-containing polycyclic aromatic hydrocarbons (PAHs) and metal(loid)s on preschool children

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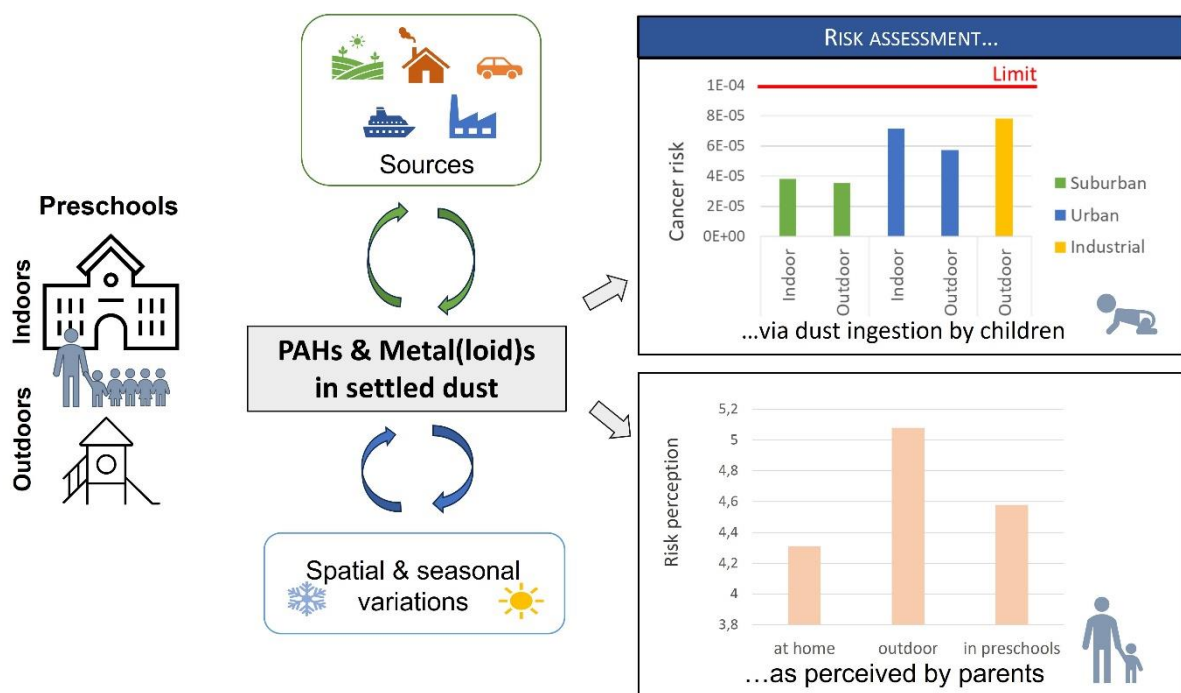
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## Highlights

1. Dust' PAHs and metal(loid)s content varied spatially, but little seasonally.
2. Input of PAHs and metal(loid)s was higher in industrial or urban schools.
3. PAHs and metal(loid)s came mainly from materials, industry, and traffic.
4. Playground areas had unacceptable levels of cancer risk due to metal(loid)s.
5. Parents believed the risk of exposure was higher in open air situation than indoor.



## Abstract

Settled dust can function as a pollutant sink for compounds, such as polycyclic aromatic hydrocarbons (PAHs) and metal(loid)s (MMs), which may lead to health issues. Thus, dust represents a hazard specifically for young children, because of their vulnerability and hand-to-mouth behavior favoring dust ingestion.

The aim of the present study was to explore the influence of the season and the microenvironment on the concentrations of 15 PAHs and 17 MMs in indoor and outdoor settled dust in three preschools (suburban, urban, and industrial). Second, the potential sources and health risks among children associated with dust PAHs and MMs were assessed. Third, domestic factors (risk perception, knowledge and parental style) were described to explore protective parental behaviors toward dust hazards.

The suburban preschool had the lowest concentrations of dust PAHs and MMs, while the industrial and urban preschools had higher but similar concentrations. Seasonal tendencies were not clearly observed. Indoor dusts reflected the outdoor environment, even if specific indoor sources were noted. Source analysis indicated mainly vehicular emissions, material release, and pyrogenic or industrial sources. The noncancer health risks were nonexistent, but potential cancer health risks (between  $1.10^{-6}$  and  $1.10^{-4}$ ) occurred at all sampling locations. Notably, the highest cancer risk was observed in a playground area ( $> 1.10^{-4}$ ) and material release should be further addressed. Whereas we assessed higher risk indoors, parents perceived a higher risk in the open-air environment and at the preschool than at home. They also perceived a lower risk for their own children, revealing an optimism bias, which reduces parental anxiety.

## Keywords

Children health risk, ingestion exposure pathway, indoor and outdoor dust, positive matrix factorization, risk knowledge and perception, settled dust.

## 1-Introduction

Thousands of chemical products, stemming from natural or anthropogenic sources, are dispersed in the environment. Exposure to these mixtures during one's lifetime could lead to health issues worldwide, which currently cause notable political and societal concerns. Among them, polycyclic aromatic hydrocarbons (PAHs) and metals and metalloids (MMs) are ubiquitous in all environmental compartments (Bidar *et al.*, 2020; Dai *et al.*, 2022; Kim *et al.*, 2013), including settled dust, which can function as a sink for these pollutants (Maertens *et al.*, 2008; Plumejeaud *et al.*, 2016).

PAHs and MMs can be formed through natural phenomena, such as erosion, volcanic eruptions, wildfires, and the water cycle. Human activities, including mining industrial activities, smelters, fuel combustion, and farming cause important inputs of MMs into outdoor environments (Alloway, 2012; Dingle *et al.*, 2021; Galażyn-Sidorczuk *et al.*, 2007; Mastro *et al.*, 2019). Linked to their pyrogenic sources (incomplete combustion of biomass, Skrbic *et al.*, 2021) or petrogenic sources (ATSDR, 1995; Budzinski *et al.*, 1997), PAHs are also emitted through human activities: motor vehicle emissions, petrochemical industrial processes, and controlled fires for farming. Indoor pollutants can originate from outdoor inputs and indoor material or activities such as paint and electronic devices for MMs and heating, cooking, candle burning and incense burning for PAHs (WHO, 2010).

The environmental concentrations of MMs and PAHs can be influenced by seasonal and spatial factors (Longhin *et al.*, 2013; Putaud *et al.*, 2010), since human activities vary between seasons (e.g., heating in winter), and weather influences the degradation of contaminants (e.g., photolysis). On a spatial scale, human activities depend on territories and their usages. To discriminate between PAH sources (petrogenic or pyrogenic), parent PAH ratios have been extensively used in different environmental compartments, including settled dust (Lim *et al.*, 2021; Skrbic *et al.*, 2019). Chemometric approaches can also be applied, such as the positive matrix factorization (PMF) model (Lim *et al.*, 2021), a multivariate factor analysis tool developed by the United States Environmental Protection Agency (US EPA) to investigate organic and inorganic pollutant sources.

Exposure to metallic elements and PAHs may cause numerous health effects. MMs can induce dermal, cardiovascular, renal, hepatic and neurotoxicity phenomena (Tchounwou *et al.*, 2012). A few trace metals are considered carcinogens by the International Agency for Research on Cancer (IARC, 2022). PAHs can increase the risk of respiratory cardiovascular diseases and cognitive development delays (WHO, 2010). Only benzo[a]pyrene (BaP) is considered a carcinogen by the IARC (Group 1). However, among the 16 US EPA priority PAHs, seven are considered as probable (Group 2A) or possible (Group 2B) human carcinogens by the IARC.

Children below six years old comprise the most sensitive population to environmental pollution. Their vital organs are still developing and their barriers— skin membrane, alveolar-capillary membrane, blood–brain barrier—are highly permeable, thus enabling the passage of contaminants (Trasande et Thurston, 2005; Walker-Smith et Macdonald, 1989). Their metabolic and immune systems are still immature, and their intake by body weight is higher than that among adults (Lu and Rosenbaum, 2014). Because of their exploring behaviors, children experience higher exposure than any other population to settled dust or soils (Moya *et al.*, 2004) and may ingest up to 100 mg of particles per day (US EPA, 2017).

The preschool is the place where children spend the most time, second only to their home. The comprehensive characterization of settled dust at preschools is of concern to ensure children’s safety and sustainable urbanization. Preschools also provide a common environment for several children at the same time and limit individual behavioral biases inevitable in in-house dust studies (e.g., tobacco smoking, cooking, heating, and cleaning practices). The numerous comings and goings at school between the outside and inside environments at school are also of interest to improve the understanding of outdoor-to-indoor dust inputs.

However, settled dust at preschools and its seasonal and spatial variations in heavily populated and industrial areas have rarely been investigated, whereas preschools constitute a common environment to many coastal dwellers in both northern and southern countries. Moreover, studies tend to focus either on PAHs or MMs, although they are ubiquitous and generally present together, both types of compounds are carcinogenic and children are exposed to both substances through dust (Maertens *et al.*, 2008; Rasmussen et al., 2001; Škrbić et al., 2018a, 2019). Literature on the perceived risk of exposure among young children to settled dust is also scarce. Qualitative studies on settled dust exposure in the household have described an increased concern among new parents with young children exposed to indoor hazards (Altman et al., 2008; Crighton et al., 2013). However, quantitative studies comparing the perceived risks of settled dust among young children are lacking (Crighton et al., 2013). The studies of the measured chemical risks and human perceived risks are generally disjointed since they fall within the remit of exact sciences on one hand and the human sciences on the other hand. However, the two aspects must be compared to formulate efficient government warnings and to improve risk communication and mitigation.

This research aimed to address these different gaps. Fifteen PAHs and 17 MMs were characterized in indoor and outdoor settled dust collected in three preschools in one city (urban) and two towns (industrial and suburban), both in winter and summer, to ascertain the influences of the microenvironment and seasonal practices on their concentrations. Parent PAH ratios and a PMF model

were applied to better understand the sources of both pollutant families. The risk assessment approach offers a quick overview of the health risks among children, without invasive sampling (US EPA, 1989). Thus, the noncarcinogenic risk and incremental lifetime cancer risk (ILCR) were calculated indoors and outdoors at preschools. In parallel to risk assessment in collective settings, we also investigated psychosocial variables (risk knowledge, risk perception and parental style) capable of predicting increased or reduced exposure of young children to settled dust, i.e., which factors predict the frequency of risk reduction measures in households (e.g., surface cleaning).

## 2-Materials and methods

### *2.1-Study sites, sample collection and preparation*

The three preschools are located in Bouches-du-Rhône, a department in southern France (Figure SI-1.1). The details for each preschool are provided in Table SI-1.2. The industrial preschool (IPS) is in Port-Saint-Louis-du-Rhône, a town of 8,500 inhabitants (120 inhab./km<sup>2</sup>), only 10 km away from one of the largest French industrial areas (approximately 30 SEVESO high-risk industries) and the western part of the harbor of Marseille-Fos (80 Mt per year of merchandise). The urban preschool (UPS) is in Marseille, the second largest city in France with 870,000 inhabitants (3,620 inhab./km<sup>2</sup>), and it is characterized by urbanized land (46% of the total land use). The preschool neighborhood is undergoing urban renewal, with industrial wastelands nearby. The eastern part of the harbor of Marseille-Fos (over 3 million passengers per year) and a frequented highway are both less than 500 m away. Therefore, the preschool is in a complex urban environment. The suburban preschool (SPS) is in Trets with 10,000 inhabitants (150 inhab./km<sup>2</sup>), a town characterized by the importance of forests and seminatural environments (53% of the total land use) and is situated at the doorstep of the Sainte-Baume regional nature park.

Each preschool was sampled once a week for four weeks to obtain a one-month composite sample and enough matter for analyses. In each preschool, four locations (classroom, dormitory, courtyard, and playground area) were sampled by gently sweeping with brushes and dustpans (surface areas > 40 m<sup>2</sup>). One set of brushes and dustpans was allocated to one location and one season to avoid cross-contamination. Sampling occurred during the school attendance periods in the heating (winter 2015-2016) and the non-heating seasons (summer 2016) (Table SI-1.2). The samples were dried at 40 °C for 24 hours and passed through a 250-µm mesh stainless sieve to remove large particles, hair, fibers, and other impurities and to obtain the finer fraction (0-250 µm), likelier to stick to the hands and classified as dust. The samples were stored in aluminum trays until analysis (< 8 months).

## 2.2- PAH and MM analyses.

Briefly, 15 out of the 16 PAHs listed by the US EPA, namely naphthalene (Nap), acenaphthene (Ac), fluorene (Flu), phenanthrene (Phe), anthracene (Ant), fluoranthene (Fla), pyrene (Pyr), benzo(a)anthracene (BaA), chrysene (Chr), benzo(b)fluoranthene (BbF), benzo(k)fluoranthene (BkF), benzo(a)pyrene (BaP), dibenzo(a,h)anthracene (dBahA), benzo(g,h,i)perylene (BghiP), and indeno(1,2,3-c,d)pyrene (IcdP), were extracted from the dust samples (200 mg) by pressurized fluid extraction with a mixture of dichloromethane and methanol. After clean-up and reconcentration processes, the extracts were analyzed by ultrahigh performance liquid chromatography (UHPLC, Perkin Elmer Altus) with a programmed fluorescence detector (PFD, Perkin Elmer) (Mbusnum et al., 2020 ; Vergnoux et al., 2011).

The 17 inorganic elements studied, i.e. Al, As, Cd, Co, Cr, Cu, Fe, Mo, Mn, Ni, Pb, Sb, Th, Ti, U, V, and Zn, were determined via inductively coupled plasma-mass spectrometry (ICP-MS, NexION® 300 X, Perkin Elmer, MA, USA) after the dust samples (100 mg) were digested with *aqua regia* (HNO<sub>3</sub> 65% and HCl 35%) for 12 h at 140 °C (Plumejeaud et al., 2016).

The QA/QC procedures included method reagent blanks and the analysis of certified reference materials of dust. The limits of detection ranged from  $9.10^{-4}$  to 0.3 µg/g for MMs and from 0.21 to 1.04 ng/g for PAHs. The methods recoveries in certified matrices ranged from 68.5% to 102% with a mean of 93.1% for MMs and from 73 to 113% with a mean of 78% for PAHs, except for Nap, Ace and Flu, which had recoveries of 22-42% due to co-evaporation during the reconcentration step.

The analytical procedures are detailed in Text SI-2.1, and the the QA/QC for PAHs and MMs analyses are reported in Tables SI-2.2 and SI-2.3, respectively.

## 2.3- Source apportionment.

First, diagnostic PAH ratios were applied to investigate the PAH origins in settled dust, as this approach is largely accepted in the scientific community to evaluate PAH sources (Ali et al., 2016 ; Franco et al., 2017 ; Ravindra et al., 2008).

To study both PAH and MM sources, positive matrix factorization (PMF; EPA PMF 5.0) was applied. This model extracts factors from a dataset with multiple variables to help understand how sources contribute to the input of organic and inorganic contaminants in settled dust. One dataset was treated according to the US EPA's user guide for the PMF 5.0 (24 samples x 32 contaminants) (Norris et al., 2014). The optimal number of factors was determined by multiple model runs to examine the effect of the assigned number of factors on the results, which are both physically meaningful and coherent

with the volume of input data. After obtaining the optimal factors, the model was run 20 times with a random seed. All runs converged to a global minimum.

#### *2.4-Health risk assessment for children through ingestion.*

We assessed the health risks of children exposed to dust by ingestion by applying the equations of the US EPA Exposure Handbook (US EPA, 2011). The estimated inhalation exposure was negligible, as only particles < 10 µm are breathable (Owen *et al.*, 1992). Particles cannot cross a healthy skin barrier, and only 13% of PAHs may be absorbed via the dermal route (US EPA, 2004; Wester *et al.*, 1990). Hence, oral ingestion is expected to be the main exposure pathway in our case study. The necessary data were obtained from the US EPA Exposure Handbook and the risk assessment information system (Table SI-2.4, RAIS, 2021; US EPA, 2011, 2017). The description of the methodology and the equations are given in Text SI-2.5. Briefly, for noncancer risks, average oral daily doses (ADD) were calculated. Then, these ADDs were divided by the reference doses to obtain the hazard quotient (HQ). The sum of the HQs gave the hazard index (HI). If  $HI < 1$ , adverse health effects are rare, whereas  $HI > 1$  indicates a potential adverse health risk (Aguilera *et al.*, 2021 ; Zivancev *et al.*, 2019). For cancer risks, the incremental lifetime cancer risk (ILCR) was applied to PAHs and carcinogenic MMs (As, Cr, Ni, and Pb). An ILCR value  $> 10^{-4}$  is considered an unacceptable risk and an ILCR value  $\leq 10^{-6}$  is considered an acceptable risk. In between, the risk is considered potential (Aguilera *et al.*, 2021 ; Zivancev *et al.*, 2019).

#### *2.5-Risk analysis at the household level: Parental knowledge, perception, and protective behavior*

Families in the preschool area were queried through online questionnaires to assess what parents of young children (1) know or how they are informed about the risks associated with settled dust, (2) how they perceive settled dust as risky to their own children, and (3) how they behave in relation to risk knowledge and perceived risks (e.g., clean surfaces and regularly open windows). The questionnaire contained self-reported items (questions or statements) to which participants responded through six-point scales — (1) totally disagree to (6) totally agree. These items were then integrated into composite variables of settled dust cleaning, knowledge, risk perception and protective behavior for each participant.

These variables provide a description of the household context in which young children are exposed to settled dust. As mentioned above, this study relies on parents' self-reported information, i.e., dust samples were not collected at their households. Participants were all responsible for children under 10 years old and were mostly contacted through parent-school associations in the same geographical area of the studied preschools (Aix-Marseille metropole, Southeast France).

A pre-study occurred in June 2020 (N = 50 participants), and participants were asked about the five ideas, images, and concepts they associated the most to the wording “fine particles” (Text SI-2.6). The pre-study questionnaire indicated that cleaning behaviors can be described in widely different ways in relation to different parts of the household – kitchen, WC, outside environments. In order to better understand how French households, refer to different types of household cleaning processes, an ad hoc questionnaire disseminated prior to the main questionnaire (March 2021) asked local families to describe different types of household chores. This ad hoc questionnaire allowed us to focus our questions around ‘dust cleaning’: mopping, vacuum cleaning, and opening windows. Based on these pre-studies, the main questionnaire study occurred in April 2021 (N = 212 participants) (Text SI-2.6). This questionnaire contained three sections with predictors that were later entered in a multiple regression model. The outcome variable of the regression model was domestic cleaning behavior: how often and when do families clean settled dust (cleaning behavior). The predictive variables were (1) what parents knew about settled dust and household air quality (knowledge); and (2) how they perceived risks associated with settled dust (risk perception). This multiple regression model also contained ‘control variables’ corresponding to socioeconomic and psychosocial variables that could also explain cleaning behavior: parent gender, age of the youngest child, and parenting style.

### 3- Results and discussion

#### 3.1- Spatial and seasonal dust PAH contents

The sum of the concentrations of the 15 PAHs ( $\Sigma$ PAHs) and the associated sum of carcinogenic PAHs concentrations ( $\Sigma$ PAH<sub>carc</sub>) are presented in Table 1. The concentrations of each PAH in all the samples are reported in SI-3, except IPS indoor samples, where not enough material could be collected. A comparison with literature data is provided in SI-3.6.

$\Sigma$ PAHs in outdoor dust (courtyard + playground) varied between 245.5 ng/g and 5007.5 ng/g (Table 1). SPS had the lowest concentrations of PAHs out of the three preschools and fell in the lowest ranges of values measured in different countries (Table SI-3.6). The median SPS value was higher than that previously reported in Serbia and was very close to that reported in Egypt (Hassanien *et al.*, 2008), but in these last two cases, the maximum values were 5 times higher than those of the SPS. The low PAH concentrations at the SPS could be attributed to the low traffic density and weak industrial activities in its vicinity. PAHs were spread over a wider range (668.2-5007.5 ng/g) in the UPS than in the IPS (1448.3-3415.7 ng/g), but their medians were close (1879.1 ng/g and 2167.2 ng/g, respectively). The PAH concentrations in the UPS and IPS were higher than those in Serbia, Nigeria, and Egypt (Hassanien *et al.*, 2008; Ossai *et al.*, 2021; Škrbić *et al.*, 2019). Both preschools are in dense traffic, harbor, and industrial microenvironments. However, the PAH concentrations in the UPS and IPS were lower than

those in China, India and the USA, where highly dense traffic can be assumed (Masto *et al.*, 2019; Ossai *et al.*, 2021; Škrbić *et al.*, 2019; Shen *et al.*, 2022; Van Metre *et al.*, 2008).

ΣPAHs in indoor dust (class + dorm) varied between 219.3 ng/g and 4029.5 ng/g depending on the preschool microenvironment (Table 1). ΣPAHs in the UPS were 5 to 10 times higher than those in the SPS, where the concentrations were similar to the lowest ranges of ΣPAHs reported in previous studies (Table SI-3.6). The concentrations measured in the UPS were two times higher than those measured in other European studies. The median was 2749.1 ng/g in the UPS *versus* 1320 ng/g in preschools in Sweden, and 1404 ng/g in households in Serbia (Lim *et al.*, 2021; Živančev *et al.*, 2022). The concentrations measured in a Nigerian coastal city were also lower (1598 ng/g indoors) (Ossai *et al.*, 2021). Nonetheless, the indoor dust PAH concentrations measured in Canada and China were at least twice as high as those measured in the UPS (Maertens *et al.*, 2008; Kang *et al.*, 2011; Shen *et al.*, 2022).

According to the lowest ΣPAHs (Table 1), the SPS had the lowest ΣPAH<sub>carc</sub>, both indoor and outdoor, and close to the indoor and outdoor concentrations found in Serbia and outdoor concentrations measured in Egypt (Hassanien *et al.*, 2008; Škrbić *et al.*, 2019; Živančev *et al.*, 2022). The UPS had a similar indoor median of PAH<sub>carc</sub> as that in households in China, but with a narrower range, certainly due to a higher homogeneity in preschool rooms than in households (Kang *et al.*, 2011). The outdoor carcinogenic concentrations in the UPS and IPS were lower than those reported in China and India (Masto *et al.*, 2019; Shen *et al.*, 2022). The concentrations in Nigeria were in between the concentrations in the SPS and in the UPS and IPS.

Outdoor dust was dominated by Phe, Flu, and Pyr in all microenvironments and to a lesser extent by B(a)A, Chr, and B(b)F in the urban and industrial microenvironments. The PAH profiles were dominated by three-four ring PAHs (Figure SI-3.5), as already observed in dust (Ali *et al.*, 2016; Kang *et al.*, 2011; Živančev *et al.*, 2022). In addition, higher molecular weight PAHs were present at notable concentrations in the industrial and urban preschools due to the wide array of human activities. Regardless of the preschool, the outdoor dust PAH contents were higher in the playground than in the courtyard. PAHs are likely released from the impact-attenuating coating at playgrounds, as recently mentioned (Pham, 2022).

The same six major PAHs were encountered in indoor dust. Notable concentrations of Nap, Ace and dBahA were also present in indoor dust, whereas lower concentrations were measured outside. Naphthalene is an intermediate compound in the manufacture of phthalic anhydride (more than 60% of production) used to produce phthalates, plasticizers, resins, dyes, and insect repellents. It is also used in the manufacture of surfactants and as a moth repellent. Acenaphthene is an intermediate substance in the manufacture of dyes and plastics and is used as an insecticide and fungicide. Thus,

the presence of these LMW PAHs is certainly due to indoor air pollution in the SPS and UPS. DBahA in indoor dust can originate from outdoor inputs, as no indoor sources could be identified. This PAH is present in bitumen, asphalt, tar, coal or even surficial coatings at playgrounds. It is also a marker of vehicular exhaust, further explaining its high concentration in the UPS, which is located in the metropole of Marseille, and fine particles emitted by exhaust are more susceptible to indoor infiltration and could be a source of contamination (Tofful *et al.*, 2021). Moreover, the UPS buildings are prefabricated buildings, with little insulation, causing more entries of finer particles into the classroom and the dormitory. This fraction of finer particles contains high concentrations of pollutants due to their high specific surface area and could explain the high concentrations measured in indoor settled dust in the UPS (Franco *et al.*, 2017; Lorenzi *et al.*, 2011).

In the urban and industrial microenvironments, there was little seasonal variation in the PAH distribution by ring number. In the suburban microenvironment, there was seasonal variation outdoors with an increase in two and three rings PAH, possibly linked to the use of wood burners in winter, as previously reported by Škrbić *et al.*, 2018b. The outdoor dust PAHs showed slightly higher contents of PAHs in winter in the SPS and UPS (except the playground), whereas an opposite trend was observed in the IPS. It is considered that domestic heating yields a greater contribution in urban and suburban residency areas than in industrialized zones. In summer, higher PAH concentrations were encountered in indoor dust of the SPS and UPS due to the higher outdoor input because of natural aeration (opening windows/doors for breeze), higher mobility of dry particles, and higher leaching of floor-covering material at high summer temperatures.

### *3.2-Spatial and seasonal dust metal(loid)s contents.*

The sum of MMs and the associated carcinogenic concentrations are presented in Table 1. The concentrations of all measured metals and metalloids (MMs) are presented in SI-4, except for the IPS indoor sample, as there was not enough matter. A comparison with literature data is presented in SI-4.5.

The sum of metal(loid)s ( $\Sigma$ MMs) in outdoor dusts (courtyard + playground) ranged from 16967.9  $\mu\text{g/g}$  to 57630.6  $\mu\text{g/g}$  (Table 2). Once again, the SPS had the lowest concentrations of the three preschools. When comparing the median of 7 MMs to that in a Serbian study, we obtained similar concentrations (Škrbić *et al.*, 2018a). The UPS had the highest and widest concentration range of MMs. The concentrations measured in street dust in Ottawa were two to four times higher than those measured in this study (Rasmussen *et al.*, 2001). The concentrations in the UPS and IPS were of the same order of magnitude as those measured in soil sampled in kindergartens in Armenia (Tepanosyan *et al.*, 2017). Highway dust in the Greater Toronto Area had the highest concentrations of MMs among the studies

summarized in Table SI-4.5 (188751.8  $\mu\text{g/g}$ ) and was four times higher than those found in the UPS, the closest preschool to highways (Nazzal et al., 2012).

$\Sigma\text{MMs}$  in indoor dust (class + dorm) varied between 15154.4  $\mu\text{g/g}$  and 43846.3  $\mu\text{g/g}$  (Table 1). The UPS dust contained more MMs than the SPS dust. The concentrations reported for Nigerian classrooms (median of 10839.7  $\mu\text{g/g}$ ) and Portuguese households (median of 13522.9  $\mu\text{g/g}$ ) were lower than those in our study, equal to 25900.1  $\mu\text{g/g}$  and 36500.9  $\mu\text{g/g}$  in the SPS and UPS respectively (Table SI-4.5) (Olujimi et al., 2015; Plumejeaud et al., 2016). However, the concentrations were two times lower than those measured in Canadian households (Rasmussen et al., 2001). Other studies did not include as many MMs, therefore we compared only equivalent sums of MMs. Our median  $\Sigma\text{9MMs}$  indicated that the metallic load of dust was lower in our preschools than in nursery schools in Xi'an, China (Lu et al., 2014), but our median  $\Sigma\text{12MMs}$  indicated that the concentrations were higher than in schools and households of Henan, China (Cao et al., 2016). Finally, when comparing our median  $\Sigma\text{8MMs}$  to the concentrations measured in Malaysian nursery schools, we found that our samples contained approximately four to six times more MMs (Darus et al., 2012).

Carcinogenic MMs, with mostly anthropogenic origins, contributed less than 1.5% to the total metallic load in settled dust. The SPS had the lowest concentrations, both indoors and outdoors, whereas the IPS had the highest concentrations outdoors. Overall, the indoor samples of the preschools had lower concentrations of  $\Sigma\text{MM}_{\text{carc}}$  than those in Hunan Province of China, Nigeria, Portugal, and Canada (Table SI-4.5) (Cao et al., 2016; Olujimi et al., 2015; Plumejeaud et al., 2016; Rasmussen et al., 2001). Our indoor samples had similar concentrations to those reported in China but contained two to five times more carcinogenic MMs than those mentioned in the Malaysian study (Darus et al., 2012; Lu et al., 2014). The outdoor samples had lower concentrations of carcinogenic MMs than those reported in India and in the Greater Toronto Area, Canada (Masto et al., 2019; Nazzal et al., 2012). The concentrations in our study were equivalent to those in Armenia and higher than those in Serbia and Ottawa, Canada (Škrbić et al., 2018a; Rasmussen et al., 2001; Tepanosyan et al., 2017).

The major contributors were Al and Fe, followed by Zn, Ti and Mn, which are naturally present in the lithosphere. The 13 other elements contributed less than 2% to the metallic load in settled dust. Slight seasonal and spatial variations were observed in the contribution profiles of the three preschools, apart from Pb. The latter had far higher concentrations in the UPS and IPS than in the SPS, which is indicative of more anthropogenic activities in both areas. Globally, the indoor and outdoor contribution profiles were quite similar, suggesting that outdoor sources were the main contributors. However, Zn was three times higher in indoor dust, especially in dormitories and Sb was particularly high indoors, especially in the SPS (61.55  $\mu\text{g/g}$  in summer and 117  $\mu\text{g/g}$  in winter), up to 8 times more

than in the UPS, whereas only low concentrations of Sb (approximately 1 µg/g) were measured outdoors. These two MMs should partly or mainly stem from indoor origins and their enrichment in indoor dust has also been observed elsewhere (Marinho-Reis *et al.*, 2018). Sb trioxide is commonly used with flame retardants, while other forms of Sb are used in paints, in rubber and as a pigment, bonding agent, opacifier or fixative in ceramics (US CPSC, 2015, Turner and Filella, 2020). The unexpectedly high indoor concentrations of Sb in the SPS relative to the UPS may be due to the ageing of the wall paints, since SPS is a relatively old preschool unlike UPS and/or to the children's handiwork with enamels or ceramics. Zn is used in paints, plastics, and personal care products (Cooper and Harrison, 2009; Naito *et al.*, 2010). Its presence indoor could also be due, specifically in dormitories, to the higher concentration of Zn in toenails from children (Marinho-Reis *et al.*, 2018).

### 3.3- Source apportionment of the dust PAHs and MMs

#### 3.3.1- PAH source analysis based on diagnostic ratios

For PAHs, the most commonly applied diagnostic ratios were calculated, namely Ant/(Ant+Phe), Fla/(Fla+Pyr), BaA/(BaA+Chr), IcdP/(IcdP + BghiP) along with  $\Sigma$ LMW/ $\Sigma$ HMW and the total index as the sum of the aforementioned diagnostic ratios normalized by their respective limit value (Barreca *et al.*, 2014; Kanzari *et al.*, 2011; Škrbić *et al.*, 2018b; Tobiszewski *et al.*, 2012). To calculate these ratios, if the subset of PAH concentrations falling below the LOD were less than 60%, the concentration was set at half of the detection limit (LOD/2) (Wood *et al.*, 2005 ; Skrbic *et al.*, 2005). If number of results below LOD were higher (60-80%), we assumed a concentration equal to LOD (Skrbic *et al.*, 2005).

Petrogenic sources are uncombusted petroleum products and primarily composed of low-molecular weight (LMW) PAHs (two–three ring PAHs), while high-molecular weight (HMW) PAHs (four to six-ring PAHs) are pyrogenic products from the combustion of coal, fossil fuel, natural gas, diesel and gasoline (Baumard *et al.*, 1999, Benlahcen *et al.*, 1997, Hu *et al.*, 2014; Škrbić *et al.*, 2017). For all samples except one (SPS courtyard in winter),  $\Sigma$ LMW/ $\Sigma$ HMW was <1, suggesting a pyrogenic source (Figure SI-5.1). To specify the abovementioned pyrogenic source, we applied a combination of ratios (Fla/(Fla+Pyr) and BaA/(BaA+Chr)) (Motelay-Massei *et al.*, 2007). The BaA/(BaA+Chr) vs. Fla/(Fla+Pyr) ratios suggested that PAHs mostly originated from pyrogenic sources, fossil fuels and/or biomass/coal combustion. Two samples, with a ratio Fla/(Fla+Pyr)<0.4, contained PAHs originating from petrogenic sources (Tobiszewski and Namiesnik, 2012; Yunker *et al.*, 2002). Both were playground samples, one from the suburban preschool in summer and one from the industrial preschool in winter, and these areas are covered with shock-absorbing coating, which may contain petroleum products. The IcdP/(IcdP+BghiP) vs. Fla/(Fla+Pyr) ratios confirmed that PAHs mainly originated from pyrogenic sources, either biomass/coal or fossil fuel combustion, apart from playground samples. A sample from the dorm of

the UPS revealed input from petrogenic sources according to its IcdP/(IcdP+BghiP) ratio in summer. No clear source could be identified. However, the area where this preschool is located was undergoing renewal at the time of sampling, and construction dust can possibly contribute to unknown inputs (Wang *et al.*, 2023). To confirm our results, the total index was calculated, and the obtained results mostly were >4, confirming pyrolytic sources for the PAHs, except for the SPS in winter. However, in these cases, several PAHs had concentrations below the LOD thus certainly biased the values of the index.

The diagnostic ratios suggested that the PAHs mainly stemmed from mixtures of traffic emissions and biomass/coal combustions in the three study areas. Since these ratios are not necessarily unique by usage, as some PAHs have both petrogenic and pyrogenic sources, the relative concentrations of PAHs may not be preserved in the environment, and low concentrations of PAHs can lead to conflicting results (Galarneau *et al.*, 2008; Sofowote *et al.*, 2009; Tobiszewski and Namiesnik, 2012; Wagener *et al.*, 2010). Transportation of PAHs in the gaseous phase, adsorption onto the dust particles and photolytic degradation may modify the distribution indices (Orecchio and Mannino, 2010; Yunker *et al.*, 2002). Therefore, the ratios should be interpreted cautiously. Hence, another source analysis was performed by using PMF to refine the PAH sources and to study MMs and PAHs together.

### 3.3.2-PAH and MM source apportionment based on PMF analysis

The optimal number of factors was 4 for our dataset. Factor 1 contributed the most in the IPS and in the playground of the UPS (Figure 1). It contributed to a lesser extent in the UPS in winter. Its contribution was nonexistent in the SPS. This factor was mostly composed of PAHs, specifically as % of the species sum: Ace (79.8%) > BkF (69.4%) > BbF ≈ BaP (60-61%) > IcdP (55.8%) > Fla ≈ Pyr ≈ BaA ≈ Chr ≈ BghiP (38-48%) (Figure SI-5.2). These are mostly high-molecular weight PAHs, generated by incomplete combustion of fossil fuels and coal and linked to industrial or port emissions according to the UPS and IPS locations (Lim *et al.*, 2022; Zivancev *et al.*, 2022). Mo and Pb were the only two elements with more than 25% of the species sum. Both Pb and Mo have metallurgic sources and are found in electrical materials. Pb can also originate from chemical, electronic, and plastic industries (Alloway, 2012). This factor could be labeled as a marker of stationary sources' emissions related to industrial (IPS) and port activities (UPS).

Factor 2 contributed to all preschools, and a peak in the SPS classroom in summer was noted (Figure 1). This factor mostly contained MMs: Th (69% of species sum) > Al ≈ As ≈ Mn ≈ Ni ≈ Ti ≈ U ≈ V (50-57% of species sum) > Co ≈ Cr ≈ Fe (45-47% of species sum) (Figure SI-5.2). PAHs contributed little to this factor and mostly involved LMW PAHs. This factor may be related to different activities: smelting plants (Al, Fe, Co, Cr, Mn, V), agricultural activities (Cr, Mn) and combustion of fossil products, including oil-

fired heating (As, Al, Mn, Th, U, V) (Alloway, 2012; ATSDR, 2019). LMW PAHs can also be emitted by oil-fired heating systems and biomass combustion, especially wood (Škrbić et al., 2018b). In summer, LMW PAHs and As can be released when wildfires occur (Vergnoux *et al.*, 2011), which is frequent in Mediterranean forests. Interestingly, the location of the SPS at the doorstep of the Sainte-Baume Natural Park could further corroborate this origin and explain the summer peak noted at this preschool. One main source of Al could be the import – export activities of the Marseille-Fos harbor, as some products include bauxite and aluminum oxide from an aluminum oxide industry 20 km away. These import-export activities are done in the vicinity of the UPS preschool. Finally, the IPS is the most exposed to smelting plants and petrochemicals industries. This factor could be labeled as mixed activities.

Factor 3 contributed mostly to the UPS, and more specifically indoors (Figure 1). This factor contained, in % of the species sum, dBahA (79.8%), Cu ≈ BaA (42-46%), IcdP ≈ Mo ≈ Pb ≈ Zn ≈ Chr (30-40%) (Figure SI-5.2). DBahA is mostly linked to diesel emissions whereas IcdP, BaA and Chr can be emitted by thermal engines, thus representing vehicular and port emissions. Zn is also linked to fossil fuel combustion and tire breakdown and is used as a lubricant (Alloway, 2012; Bohemen and Janssen van de Laak, 2003; Mansha et al., 2012). Cu and Mo compounds are commonly used in automobiles (brakes, diesel engine glow plugs, engine coolants, motors, wirings, radiators, and connectors), and Pb is found in car batteries (Alloway, 2012; Barceloux, 1999; Wei *et al.*, 2010). This factor mostly represents a mixture of transport exhaust emissions resulting from combustion and nonexhaust emissions (road dust, abrasion of brakes, tires, and asphalt) and could be a marker of urban/port high-traffic environment. This is coherent with its high contribution to the UPS, located in the big city of Marseille. The high contribution in the classroom could be justified by the poor insulation of prefabricated buildings and the higher infiltration of finer particles (Tofful *et al.*, 2021), which can sorb higher concentrations of pollutants due to their higher specific surface area (Franco *et al.*, 2017; Lorenzi *et al.*, 2011).

Factor 4 predominantly contributed to indoor environments, especially in the UPS and SPS dorms in summer (Figure 1). It also contributed to a lesser extent to the UPS and IPS playgrounds and covered areas. This factor was composed of the following (in % of the species sum): Ant (97%), Nap ≈ Sb (75-78%), Flu (62.1%), Cd ≈ Phe ≈ BghiP (40-42%) (Figure SI-5.2). This factor had a high contribution of Nap and Ant relative to other factors. Nap and Ant are usually emitted by petrogenic sources (Motelay-Massei *et al.*, 2007). As mentioned earlier, playground shock-absorbent coatings may contain petroleum-derived products, which could explain the contributions of this factor to playground areas. In the case of indoor settings, the possible release of Nap, Ace and Ant from furniture, plastic floor, and paint was discussed in Section 3.1. Their releases increase at higher temperatures, thus explaining

the higher contribution of this factor in summer (Paciência et al., 2016). The high presence of Sb could be linked to the use of antimony trioxide as a flame-retardant synergist in textiles and plastics (US CPSC, 2015). Cd has also been used as a PVC stabilizer and pigment, although these uses have been reduced (Alloway, 2012). The aging and breakdown of plastic floorings and/or of furniture and/or mattress beddings indoors and of shock absorbent coating outdoors into small particles could have allowed these particles to mix with settled dust and/or the dispersion of Ace, Nap, Ant, Sb and Cd and their sorption onto indoor settled dust particles. Overall, this factor may represent material release.

### 3.4- Health Risk Assessments

All health risk assessments were performed under the case-scenario where children are unintentionally exposed to PAHs and MM in settled dust through ingestion.

Hazard quotients (HQ) were determined for at every sampling location. The HQs were below 1, indicating that no health risks were associated with a particular element in settled dust, and the HI values were below the risk limit of 1, suggesting that there were no health risks associated with the ingestion of settled dust (Table SI-6.1, Figure SI-6.2). The HI values for PAHs were negligible ( $<10^{-9}$ ). The highest value was found in the playground of the SPS in winter due to a high concentration of As, which was not found in the courtyard, suggesting release from the playground area. The concentrations of Cr and Cu also increased the HI of this sample. These three elements were once commonly used to preserve wood (CCA i.e., chromated copper arsenate, used as fungicide and termiticide on wood), and they could be leachates from wooden play structures under rain in the playground area (Bhattacharya et al., 2001; Kwon et al., 2004; Zagury et al., 2003). There were distinctive contribution profiles observed for the HI between the preschools, but there were slight seasonal and spatial variations in each preschool (Figure SI-6.3). Nonetheless, in the SPS, Sb contributed to at least 60% of the HI value in the dorm but less than 10% in the class, and As contributed between 40% and 80% to the playground HI but less than 20% to the courtyard HI. The HIs determined hereby were similar as those calculated in India and Nigeria (Table SI-6.4) (Masto et al., 2019; Olujimi et al., 2015), two to five times lower than those calculated in Mexico, Spain, China, and Serbia (Aguilera et al., 2021; Gabarron et al., 2017; Lu et al., 2014; Škrbić et al., 2018a).

ILCRs are shown in Table SI-6.1. They widely ranged from  $1,75 \cdot 10^{-6}$  to  $2,48 \cdot 10^{-4}$ . In the samples from the suburban playground area (a high concentration of As due to wood preserver use) and the industrial playground area (high concentration of Cr), ILCRs were above the unacceptable risk limit of  $1 \cdot 10^{-4}$ , corresponding to one cancer case per 10,000 inhabitants (Figure 2). All other ILCRs were between  $1 \cdot 10^{-6}$  and  $5 \cdot 10^{-5}$ , still indicating a potential cancer risk. Overall, PAHs, with concentrations one order of magnitude smaller than MMs, slightly contributed to the carcinogenic load in settled dust

(less than 2%). Nonetheless, they represented up to 6.7% of the ILCR in the UPS, with BaP and/or dBahA as the major contributors. The MM ILCR values in Spain and China were well below the acceptable risk limit of  $1.10^{-6}$ , and the MM ILCR in Armenia was within the range of the acceptable risk (Table SI-6.5) (Gabarron *et al.*, 2017; Lu *et al.*, 2014; Tepanyosan *et al.*, 2017). Our own concentrations were above the concentrations found in these studies, indicating a higher risk for children, but they were still lower than the MM ILCRs estimated in the USA (Davis *et al.*, 2021). In Brazil, the PAH ILCR was similar to that determined in the SPS, our lowest value (Franco *et al.*, 2017). Except for the SPS, our PAH ILCR concentrations were slightly above  $10^{-6}$ , the limit indicating a potential risk.

Overall, the noncancer risk was highest in the UPS, but the cancer risk was highest in the IPS. When comparing MM ILCR and PAH ILCR, it was determined that the MM ILCR was highest in the IPS driven by Cr whereas the PAH ILCR was highest in the UPS, driven by dBahA. These drivers can be linked to the type of microenvironment: dBahA is an indicator of vehicular/traffic emissions, and Cr is an indicator of industrial activities.

### *3.5- Parental knowledge, perception, and prevention behavior from dust threat to children*

The verbal association task analysis of parents, conducted in the exploratory pre-study, showed that the wording “fine particles” was mainly perceived in terms of pollution (all participants), air (9 out of 50), cars (8/50), hazard or lungs (7/50), disease (6/50), cancer (5/50), dust or asthma or diesel (4/50), indicating some knowledge, especially on outdoor pollution issues and traffic inputs. This may be related to the French government’s regular ozone pollution alerts and congruent restriction of road traffic.

The results of the main questionnaire study ( $n = 212$  participants) presented in Figure 3 and Table SI-7.1 confirmed that overall, the risk of exposure was perceived higher in open air situations than indoors, either at school or at home, despite increasing scientific communication about the risk of indoor air pollution from media and institutions in charge of air quality monitoring. Moreover, the quantitative risk assessment showed higher risks indoors than outdoors (median values in Tables SI-6.4 and SI-6.5). In addition, families tend to perceive a significantly higher risk of exposure to settled dust at school (level of risk perception of 4.6,  $p < .001$ ) or outdoors (level 5.1,  $p < .001$ ) than in the household (level 4.3; Figure 3). Other children are perceived as more exposed to settled dust than one’s own, an optimism bias that is significant within the context of the preschool ( $p < .05$ ). This tendency is also observed at home and outdoors, but it is statistically nonsignificant. Parents therefore develop psychological strategies to convince themselves that their children’s exposure to this risk is reduced, due to cognitive bias known as positive illusion.

The self-reported measure of cleaning behavior was our indicator of the risk of settled dust to young children. This measure was regarded as the outcome variable of multiple linear regression. The predictive variables were the following (Tables SI-7.2 and SI-7.3): settled dust risk perception, settled dust knowledge, parenting style and socioeconomically controlled parent gender and age of the youngest child ( $\text{AdjR}^2 = 0.14$ ;  $F(5,162) = 7.87$ ,  $p < .001$ ). The regression analysis showed that the only significant predictor of cleaning behavior was the parenting style ( $B = .40$ ,  $p < .001$ ). This suggests that the type of family dynamics around rule settings is more important than risk knowledge of settled dust, risk perception or other socioeconomic variables (gender, children's age, and educational level).

Our results are consistent with previous qualitative descriptions of new parents' concerns regarding indoor pollution for young children, revealing optimism bias (Crighton et al., 2013; Joffe, 2003) and how these concerns are deeply intertwined with family organization around cleaning practices (Crighton *et al.*, 2013).

#### 4-Conclusion

Distinctive loads of PAHs and MMs were measured in dust according to the microenvironment of the preschool, i.e., higher in preschools within urban and industrial contexts. Seasonal variations were not clearly observed. The PAH and MM contents in indoor dust are related to those in outdoor dust, through infiltration and penetration of particles produced by vehicular traffic and biomass burning. Nonetheless, indoor sources were considered for Nap, Ace, and dBahA on the one hand and for Sb and Zn on the other hand. Source apportionment identified out traffic emissions and road dust or automobile related emissions, industrial and port activities, pyrogenic sources, and material release.

Ingestion of settled dust by children at the preschools did not result in health-related events ( $\text{HI} < 1$ ). However, the estimated cancer risks were considered as potential (between  $1.10^{-6}$  and  $1.10^{-4}$ ). As, Cr, Ni, and Sb exerted the largest impact on the health risks. The highest ILCR was measured at a playground, above the unacceptable limit of  $1.10^{-4}$ , indicating hazards linked to the use of shock attenuating coatings, which might be responsible for PAHs and MMs release.

Home or school cleaning practices in densely populated or industrialized areas could also play a role in preventing young children's exposure to indoor dust. Nevertheless, we showed that these practices were deeply rooted in household practices and habits — highly dependent on the family or school organization. Such an integrative interdisciplinary approach could shed light on how to limit pollutant sources and provide information to increase the adoption of more preventive behavior in the household. It could help policymakers and architects identify risk mitigation options to improve the safety of children according to the objective of developing smart cities and sustainable urbanization. Furthermore, it could allow for global ethical reflection to help disseminate the results of

environmental research by limiting the anxiety or helplessness that this may bring to the general population.

## Author Contributions

The manuscript was written through the contributions of all authors. All authors have given approval to the final version of the manuscript.

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## Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1: Concentrations of MMs ( $\mu\text{g/g}$ ) and PAHs ( $\text{ng/g}$ ) in settled dust in the different locations.

Concentrations of MMs and PAHs in settled dust						
Locations	Number of MMs		Concentration ( $\mu\text{g/g}$ )			
			Min	Max	Median	Mean
<i>Indoor</i>						
Suburban preschool, Trets, France	17	$\Sigma\text{MMs}$	15 154	27 494	25 900	22 850
	10	$\Sigma\text{MM}_{\text{carc}}$	112	269	206	196
Urban preschool, Marseille, France	17	$\Sigma\text{MMs}$	29 389	43 846	36 501	36 579
	10	$\Sigma\text{MM}_{\text{carc}}$	317	400	336	351
<i>Outdoor</i>						
Suburban preschool, Trets, France	17	$\Sigma\text{MMs}$	16 968	28 068	24 274	23 396
	10	$\Sigma\text{MM}_{\text{carc}}$	75	355	109	162
Urban preschool, Marseille, France	17	$\Sigma\text{MMs}$	33 957	57 631	49 413	47 604
	10	$\Sigma\text{MM}_{\text{carc}}$	209	352	284	282
Industrial preschool, Port Saint Louis du Rhône, France	17	$\Sigma\text{MMs}$	32 560	48 720	38 313	39 476
	10	$\Sigma\text{MM}_{\text{carc}}$	276	403	321	330
Location	Number of PAHs		Concentration ( $\text{ng/g}$ )			
			Min	Max	Median	Mean
<i>Indoor</i>						
Suburban preschool	15	$\Sigma\text{PAHs}$	219	1 557	486	754
	8	$\Sigma\text{PAH}_{\text{carc}}$	37	805	113	318
Urban preschool	15	$\Sigma\text{PAHs}$	2 612	4 029	2 742	3 031
	8	$\Sigma\text{PAH}_{\text{carc}}$	1 275	2 311	1 580	1 687
<i>Outdoor</i>						
Suburban preschool, Trets, France	15	$\Sigma\text{PAHs}$	245	560	308	355
	8	$\Sigma\text{PAH}_{\text{carc}}$	49	129	93	91
Urban preschool, Marseille, France	15	$\Sigma\text{PAHs}$	668	5 007	1 879	2 358
	8	$\Sigma\text{PAH}_{\text{carc}}$	296	2 565	930	1 180
Industrial preschool, Port Saint Louis du Rhône	15	$\Sigma\text{PAHs}$	1 448	3 416	2 167	2 300
	8	$\Sigma\text{PAH}_{\text{carc}}$	821	1 757	1 031	1 160

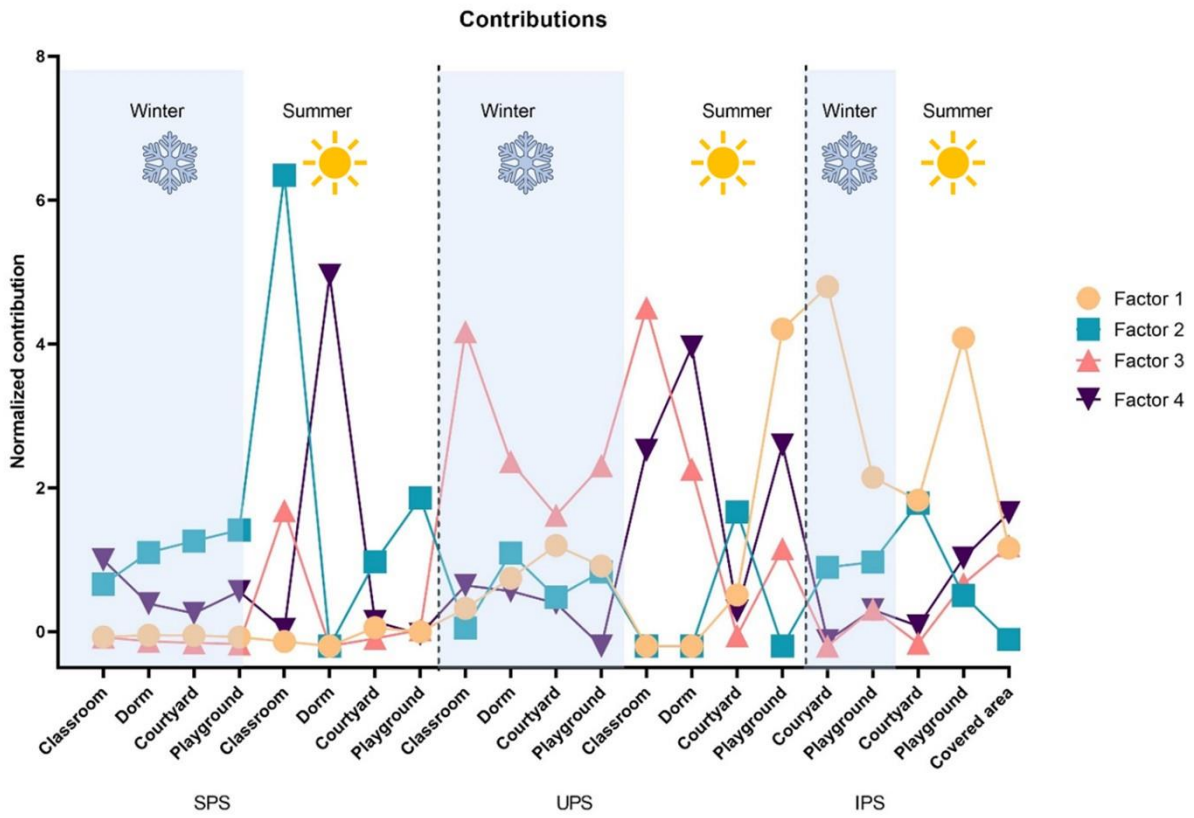


Figure 1 : Contributions of the 4 factors in the different sampling locations according to the PMF analysis. SPS = Suburban preschool. UPS = Urban preschool. IPS = Industrial preschool.

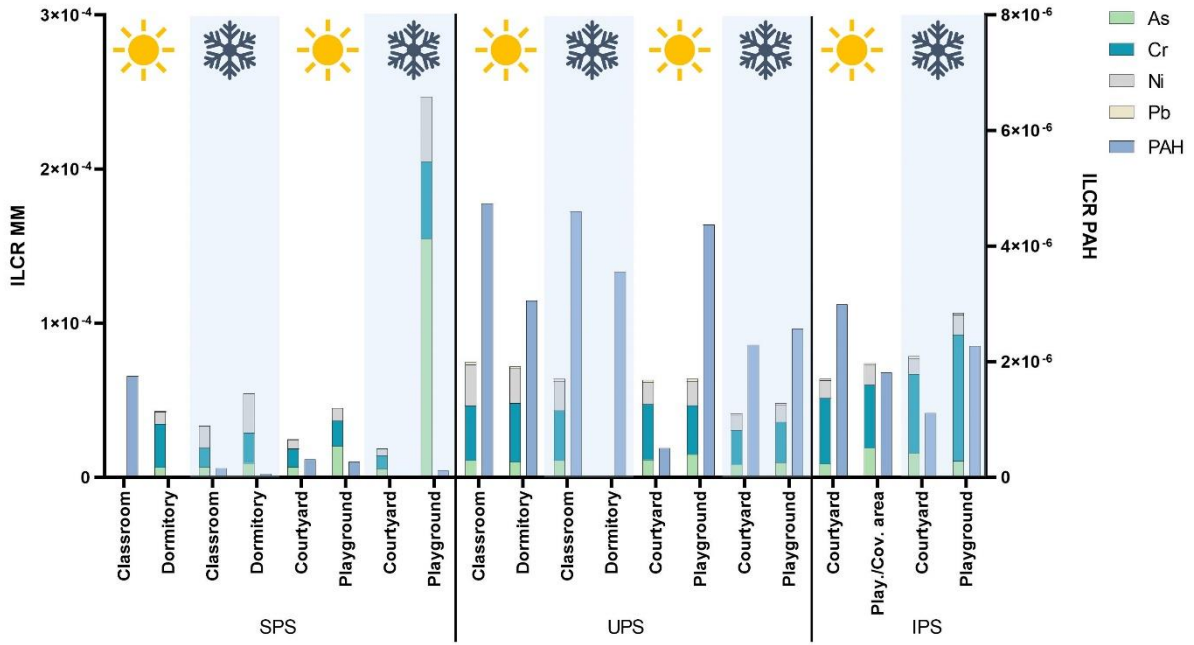


Figure 2 : Carcinogenic risk assessment for each sampling location. SPS = Suburban preschool. UPS = Urban preschool. IPS = Industrial preschool.

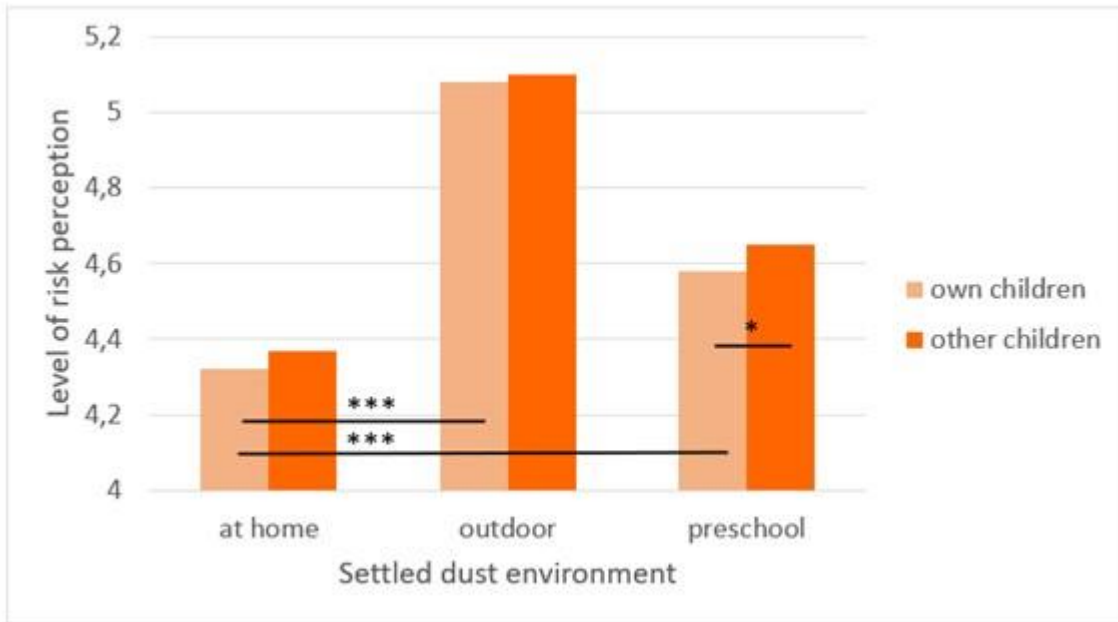


Figure 3 : Parental perception of the risk of exposure of their children to settled dust in three different settings (home, outdoor, preschool).

Toward an interdisciplinary approach in the assessment of children adverse health effect related to polycyclic aromatic hydrocarbons (PAHs) and metal(loid)s in settled dust at preschools.

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Table SI-7.2: Regression model of 'household cleaning behaviour' (outcome variable).

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### **SI-8: Bibliography**

## SI-1 – Sampling location

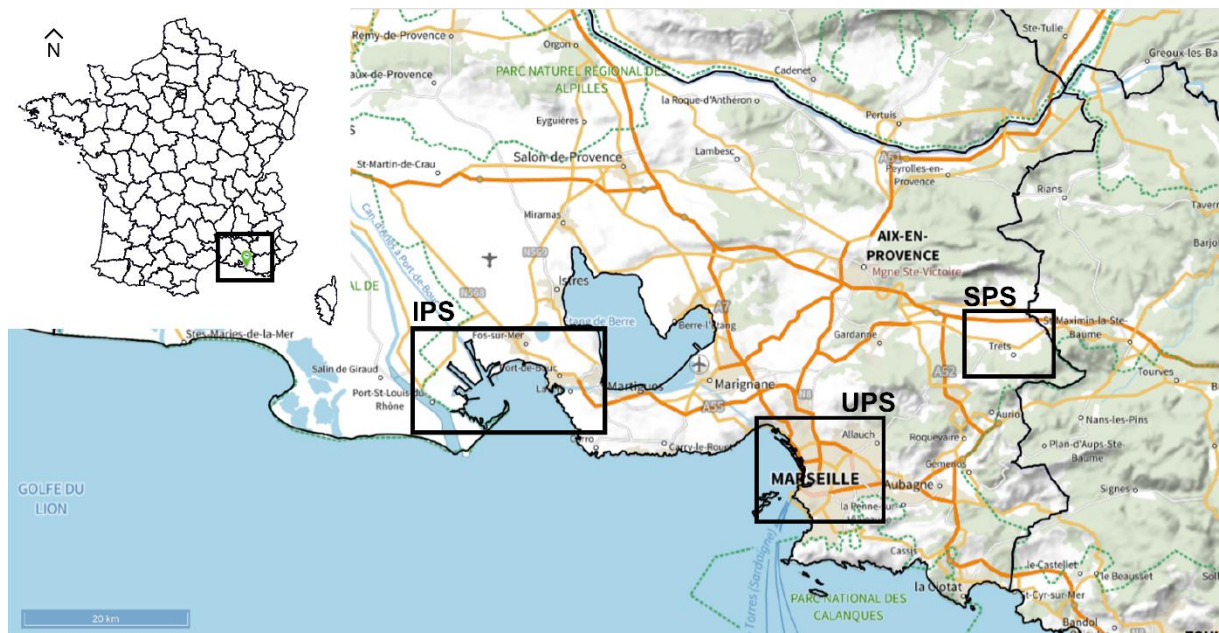


Figure SI-1.1: Map of the Bouches-du-Rhône department localizing the microenvironment of each preschool.

Table SI-1.2: Description of the preschools and the samples collected in each preschool.

Microenvironment	Location	No. Children	Season		Sampling sites	Description
Suburban	Trets	160	Summer	Indoor	Classroom	Plastic floorings
					Dorm	
			Winter		Classroom	
					Dorm	
			Summer	Outdoor	Courtyard	Paved
					Playground	Impact attenuating coating
Winter	Courtyard	Paved				
	Playground	Impact attenuating coating				
Urban	Marseille	140	Summer	Indoor	Classroom	Plastic floorings
					Dorm	
			Winter		Classroom	
					Dorm	
			Summer	Outdoor	Courtyard	Paved
					Playground	Impact attenuating coating
Winter	Courtyard	Paved				
	Playground	Impact attenuating coating				
Industrial	Port-Saint-Louis-du-Rhône	110	Summer	Indoor	Classroom	Tiled
					Dorm	
			Winter		Classroom	
					Dorm	
			Summer	Outdoor	Courtyard	Paved
					Covered courtyard	Paved
Winter	Playground	Impact attenuating coating				
	Courtyard	Paved				
Winter	Outdoor	Playground	Impact attenuating coating			

## SI-2 – Methodology

Text SI-2.1 Analytical procedures for PAH and MM quantification.

For the analyses of the 15 US-EPA PAHs, dust samples (200 mg) were mixed with Fontainebleau sand and placed in a 11 mL stainless steel cell. Pressurized fluid extraction (PFE) using an accelerated solvent extraction apparatus (ASE 200, Dionex, Sunnyvale, CA, USA) was performed with a mixture of dichloromethane (DCM, quality suprasolv, Merck) and methanol (quality hypersolv, Merck) (9:1 v/v) at 120 °C and 10 MPa in static extraction mode for 6 min twice (2 cycles). Extracts were then concentrated to dryness under a gentle stream of air and recovered in 1 mL of DCM, then transferred onto an alumina cartridge (1g/6 mL, strata alumina-N, 120 Angstrom from Phenomenex) for clean-up. PAHs were eluted with 10 mL of DCM. Solvent-exchanged into acetonitrile was done to obtain a final extract of 0.25 mL, which was filtered through Ø 4 mm PTFE syringe filter of 0.2 µm (chromacol 4-SF-02(T) from Thermo Scientific) before analysis by ultra-high performance liquid chromatography (UHPLC Perkin Elmer Altus) with programmed fluorescence detector (PFD, Perkin Elmer) equipped with a zorbax eclipse C18 separative column of 150 mm long x 2.1 mm internal diameter and 1.8 µm particle size (Agilent, USA). We injected 2 µL of sample extract and applied a mixture of acetonitrile and water at 0.35 mL/min as [mobile phase](#) starting with 40% acetonitrile (1 min), changed it within 15 min to 100% acetonitrile and held this for another 20 min. Fluorescence detection was performed in a multichannel mode (excitation wavelength: Ex and emission wavelength: Em) as follows: phenanthrene and anthracene: Ex=248 nm, Em=375 nm changing to Ex=300 nm, Em=466 nm at 14 minutes to detect indeno[1.2.3-cd]pyrene for channel A; naphthalene, acenaphthene and fluorene: Ex=270 nm, Em=324 nm changing at 10 minutes to Ex=290 nm, Em=430 nm to detect benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenzo[ah]anthracene and benzo[ghi]perylene for channel B; pyrene, benzo[a]anthracene and chrysene: Ex=270 nm, Em=385 nm for channel C and fluoranthene: Ex=280 nm, Em=462 nm for channel D.

To analyze inorganic elements, dust samples (0.1 g) were weighed with a Sartorius MP210 balance. They were first digested for 12h at 140 °C in closed teflon® flasks with 6 mL of *aqua regia* (HNO<sub>3</sub> 65% and HCl 35%) on a heating plate. After cooling, sample extracts were filtered at < 0.45 µm, acidified with HNO<sub>3</sub><sup>-</sup> (pH = 1) and the volume was adjusted to 30 mL. Extracts were kept refrigerated at 4° C in polyethylene flasks. Analysis was performed by inductively coupled plasma mass [spectrometry](#) using the Syngistix™ software (ICP-MS, NexION® 300 X from Perkin Elmer, MA, USA).

Table SI-2.2: QA/QC for PAHs analyses.

	LOD (ng/g)	SRM Data		Measured SRM data		
		Concentration (µg/g)	SD	Concentration (µg/g) (Recovery. %)	SD (n=5)	RSD (%)
Naphtalene	0.42	0.946 <sup>ncm</sup>	0.011	0.305 (32.2%)	0.021	6.89
Acenaphtene	0.21	0.197 <sup>ncm</sup>	0.04	0.043 (21.8%)	0.007	16.28
Fluorene	0.21	0.223 <sup>ncm</sup>	0.035	0.110 (49.3%)	0.002	1.82
Phenanthrene	0.21	4.03 <sup>ncm</sup>	0.06	3.553 (88.2%)	0.016	0.45
Anthracene	0.21	0.41 <sup>ncm</sup>	0.004	0.370 (90.2%)	0.004	1.08
Fluoranthene	0.21	6.24 <sup>ncm</sup>	0.08	5.946 (95.3%)	0.051	0.86
Pyrene	0.42	4.98 <sup>cm</sup>	0.14	4.280 (85.9%)	0.028	0.65
Benzo(a)anthracene	0.42	2.11 <sup>ncm</sup>	0.05	2.380 (112.8%)	0.012	0.50
Chrysene	0.42	3.05 <sup>cm</sup>	0.028	3.080 (101.0%)	0.016	0.52
Benzo(b)fluoranthene	0.42	6.18 <sup>cm</sup>	0.18	4.820 (78.0%)	0.195	4.05
Benzo(k)fluoranthene	0.42	1.7 <sup>cm</sup>	0.049	1.400 (82.3%)	0.038	2.71
Benzo(a)pyrene	1.04	2.47 <sup>ncm</sup>	0.24	1.803 (73.0%)	0.069	3.83
Dibenzo(ah)anthracene	1.04	0.294 <sup>ncm</sup>	0.002	0.226 (76.9%)	0.005	2.21
Benzo(ghj)perylene	1.04	3.97 <sup>ncm</sup>	0.04	3.831 (96.5%)	0.172	4.49
Indeno(123cd)pyrene	0.42	2.89 <sup>ncm</sup>	0.16	2.580 (89.3%)	0.135	5.23

certified mass values (cm), non-certified mass values (ncm).

QA/QC data for the PAH report the limits of detection (LOD) of the method and the measured concentrations in a standard reference material of urban dust (SRM 1649b, from National Institute of Standards and Technology, NIST), relative either to the certified mass values (cm) or to the non-certified mass values (ncm), as reported on the certificate of analysis delivered by NIST (Beauchamp *et al.*, 2021). The calibration curve was drawn by dilution in acetonitrile of a standard reference material of priority pollutant polynuclear aromatic hydrocarbons (SRM 1647e, from NIST provided by Sigma Aldrich). Recoveries from dust were established and checked for each batch of sample extraction with SRM 1649b of urban dust (NIST). Mean repeatability (expressed as RSD%, n=5) was <7% (except for Ace, RSD=16%). Recoveries >73% were obtained for all the PAHs, except for Nap, Ace, and Flu (about 35%) for which volatilization occurred during the reconcentration step. Thus, the calculated concentrations were corrected by this factor for these three analytes. In each batch of analysis sequence, duplicates of SRM 1649b were run and a blank and a calibration standard were run every 6 samples.

Table SI-2.3: QA/QC for MMs analyses

	LOD ( $\mu\text{g/g}$ )	SRM Data		Measured SRM data		
		Concentration ( $\mu\text{g/g}$ )	SD	Concentration ( $\mu\text{g/g}$ ) (Recovery. %)	SD (n=5)	RSD (%)
Al	0.3	23200 <sup>a</sup>	600	22700 (97.8%)	400	1.76
As	0.0015	7 <sup>cm</sup>	1.6	6 (85.7%)	2	33.33
Cd	0.0015	7.3 <sup>cm</sup>	3.7	5 (68.5%)	1	20.00
Co	0.0015	10 <sup>b</sup>	n.r.	9 (90.0%)	2	22.22
Cr	0.003	80 <sup>cm</sup>	22	70 (87.5%)	25	35.71
Cu	0.003	320 <sup>b</sup>	n.r.	300 (93.8%)	25	8.33
Fe	0.3	16400 <sup>a</sup>	1200	16000 (97.6%)	1500	9.38
Mo	0.0015	5.5 <sup>b</sup>	n.r.	5.2 (94.5%)	1	19.23
Mn	0.03	370 <sup>b</sup>	n.r.	350 (94.6%)	10	2.86
Ni	0.003	90 <sup>b</sup>	n.r.	85 (94.4%)	10	11.76
Pb	0.0009	85.9 <sup>cm</sup>	7.2	88 (102.4%)	10	11.36
Sb	0.03	14 <sup>b</sup>	n.r.	12 (85,7%)	1.5	12.5
Th	0.0015	4 <sup>b</sup>	n.r.	3.5 (87.5%)	0.5	14.29
Ti	0.003	4200 <sup>a</sup>	300	4000 (95.2%)	500	12.50
U	0.0015	1.6 <sup>b</sup>	n.r.	1.7 (106.3%)	0.2	11.76
V	0.003	34 <sup>b</sup>	n.r.	31 (91.2%)	2	6.45
Zn	0.03	2580 <sup>a</sup>	150	2500 (96.9%)	200	8.00

QA/QC data for the 17 studied MMs, i.e. Al, As, Cd, Co, Cr, Cu, Fe, Mo, Mn, Ni, Pb, Sb, Th, Ti, U, V, and Zn, report the method limits of detection (LOD) and the measured concentrations in standard reference materials of dust (SRM 2583 or SRM 2584, from the National Institute of Standards & Technology, NIST) relative to the certified mass values (cm), the reference mass values (a), or the information mass values (b), as written on the certificate of analysis delivered by NIST (Beauchamp *et al.*, 2021). When the standard deviation was not provided on the certificate, it is indicated not reported (n.r.) in the table. The standard reference materials of dust were analyzed using the same procedure as the samples. The recoveries ranged between 69 and 102 % and precision was <22% (except for As and Cr). For all samples' series, an acid blank (HNO<sub>3</sub> 65% and HCl 35%, Merck suprapur) was routinely prepared and analyzed.

Table SI-2.4: Risk assessment values

Reference dose (RfD, maximal acceptable oral dose for a toxic substance), cancer slope factor (CSF, used to estimate the risk of cancer associated with exposure to a carcinogenic or potentially carcinogenic substance) and toxic equivalency factor (TEF, factor indicating the degree of toxicity compared to Benzo(a)pyrene, which is given a reference value of 1) for metal(loid)s and PAHs, n.r. for not reported (Masto *et al.*, 2019; Nisbet and LaGoy, 1992; RAIS, 2021; Škrbić *et al.*, 2019).

Contaminants		Oral RfD	CSF	TEF
Metal(loid)	Al	1.00000	n.r.	n.r.
	As	0.00030	1.5	n.r.
	Cd	0.00010	n.r.	n.r.
	Co	0.00030	n.r.	n.r.
	Cr	1.50300	0.5	n.r.
	Cu	0.04000	n.r.	n.r.
	Fe	0.70000	n.r.	n.r.
	Mo	n.r.	n.r.	n.r.
	Mn	0.14000	n.r.	n.r.
	Ni	0.02000	0.5	n.r.
	Pb	n.r.	0.0085	n.r.
	Sb	0.00040	n.r.	n.r.
	Th	n.r.	n.r.	n.r.
	Ti	n.r.	n.r.	n.r.
	U	0.00020	n.r.	n.r.
	V	0.00504	n.r.	n.r.
Zn	0.30000	n.r.	n.r.	
PAH	Naphtalene	0.020	n.r.	0.001
	Acenaphtene	0.060	n.r.	0.001
	Acenaphtylene	n.r.	n.r.	0.001
	Fluorene	0.040	n.r.	0.001
	Phenanthrene	n.r.	n.r.	0.001
	Anthracene	0.300	n.r.	0.010
	Fluoranthene	0.040	n.r.	0.001
	Pyrene	0.030	n.r.	0.001
	Benzo(a)anthracene	n.r.	n.r.	0.100
	Chrysene	n.r.	n.r.	0.010
	Benzo(b)fluoranthene	n.r.	n.r.	0.100
	Benzo(k)fluoranthene	n.r.	n.r.	0.100
	Benzo(a)pyrene	0.0003	n.r.	1.000
	Dibenzo(ah)anthracene	n.r.	n.r.	1.000
	Benzo(ghj)perylene	n.r.	n.r.	0.010
Indeno(123cd)pyrene	n.r.	n.r.	0.100	
PAH equivalent BaP		n.r.	7.3	n.r.

Text SI-2.5: Risk assessment calculation

An average oral daily dose (ADD) was calculated for MMs and PAHs (Equation 1). As the concentration (C) was in  $\mu\text{g/g}$ , a conversion factor (CF) of  $10^{-6}$  had to be applied. The theoretical ingestion rate (IR) was 60 mg/day (US EPA, 2017). The exposure duration (ED) was of 6 years, and the exposure frequency (EF) was estimated to be 180 days/year at preschools (weekends and vacations excluded). The average body weight (BW) for children below 6 years old is about 15 kg. The average time (AT) was 1080 days (6 years x 180 days).

$$\text{Equation 1:}$$

$$ADD \text{ oral} = \frac{C * IR * EF * ED}{BW * AT} * CF$$

The hazard quotient (HQ) was calculated by dividing the ADD by the reference dose (RfD) obtained from the Risk Assessment Information System (RAIS, 2021) (Equation 2, see Table SI-2.3). The sum of the HQs gave the hazard index (HI) (Equation 3). A value of  $HI < 1$  indicates there is no significant non-carcinogenic risk, whereas  $HI > 1$  indicates there is a risk that a non-carcinogenic health event occurs, and this probability tends to increase when the HI increases.

$$\text{Equation 2:}$$

$$HQ \text{ oral} = \frac{ADD \text{ oral}}{RfD}$$

$$\text{Equation 3:}$$

$$HI \text{ oral} = \sum HQ \text{ oral}$$

The carcinogenic risk assessment was applied to PAHs and carcinogenic MMs (As, Ni, Pb) with a cancer slope factor (CSF) obtained from the RAIS (Table SI-2.3, RAIS, 2021). The incremental lifetime cancer risk (ILCR) was calculated according to the US EPA (US EPA, 2011). The lifetime value was set at 78 years as it represents the current life expectancy of the general American or European population according to US EPA (US EPA, 2011), even if a 70-years value has been previously commonly used in risk assessment (Chen *et al.*, 2019; Mohammedi *et al.*, 2019). We added the ILCR for each metal(loid) to obtain a metallic ILCR and we added the PAH ILCR and the metallic ILCR to obtain a global cancer risk for each location. We included a composite adjustment factor (AF) for children below 6 years old of 5.8 (Maertens *et al.*, 2008). For MM, the ILCR was the ADD multiplied by the cancer slope factor (CSF) of each compound (Equation 4), the average time (AT) being of 28470 days (78 years x 365 days) for cancer risk (US EPA, 2011).

Equation 4:

$$ILCR (MM) = ADD \text{ oral} * CSF * AF$$

For each PAH, the toxic equivalency factor (TEF) weighted the PAH concentration in dust (C in  $\mu\text{g/g}$ ) (Nisbet and LaGoy, 1992) (Equation 5). We calculated the concentration of PAHs as a toxic equivalency quantity (TEQ) by using the TEF of each PAH, to apply the ingestion CSF of BaP of 7.3, since not all the PAHs have a CSF. Thus, a unique CSF of  $7.3 \text{ (mg/kg/day)}^{-1}$  was applied to all the PAHs, as previously done (Kang *et al.*, 2011; Masto *et al.*, 2019; Shen *et al.*, 2022; Škrbić *et al.*, 2019). A conversion factor (CF) of  $10^{-6}$  had to be applied. Other parameters were identical to the ones used for the MMs.

Equation 5:

$$ILCR (PAH) = \sum \frac{(C * TEF) * IR * ED * EF}{BW * AT} * CF * CSF * AF$$

An ILCR  $\leq 10^{-6}$  indicates that the risk is lower than one in a million of a cancer occurring and is considered as an acceptable risk; an ILCR  $> 10^{-4}$  implies that there is more than one cancer case per 10 000 inhabitants and is considered as an unacceptable risk. An ILCR between these two values indicates a potential risk of cancer (Chen *et al.*, 2019).

Text SI-2.6: Pre-study and main questionnaires provided online to parents of children below 10 years old in the Aix-Marseille metropole (Southeast France).

“Hello, we are an interdisciplinary team of Aix Marseille University, and we are interested in the relationship of the families with young children regarding their environment, especially fine particles (dust with a diameter < 0.5 mm). We are asking you to carefully read the questions and to answer them as spontaneously and sincerely as possible. This questionnaire is confidential and anonymous. There are no right or wrong answers, only your personal opinion is of interest. We thank you for your participation.

1. I confirm that I have taken into consideration all the information that I have been given and I voluntarily and freely participate in this study.
2. I am a parent or a guardian of at least one child below 10 years old (included).

### **Prestudy questionnaire**

Question 1: Write in the blanks below the 5 first words that come to mind when you hear “fine particles”.

- 1:
- 2:
- 3:
- 4:
- 5:

### **Main questionnaire**

Question 1: For each sentence below, indicate your level of agreement by checking the according box.

	Strongly disagree	Disagree	Tend to disagree	Tend to agree	Agree	Strongly agree
When your children are at home, do you think they are exposed to fine particles?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
When children in general are at home, do you think that they are exposed to fine particles?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
When your children are outside, do you think they are exposed to fine particles?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
When children in general are outside, do you think they are exposed to fine particles?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
When they are at school, do you think your children are exposed to fine particles?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
When they are at school, do you think children in general are exposed to fine particles?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Do you think these particles are a danger to your children's health?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you think these particles are a danger for children's health in general?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Question 2: Please estimate your level of agreement with the statements below.

	Strongly disagree	Disagree	Tend to disagree	Tend to agree	Agree	Strongly agree
Fine particles may contain pollutants.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fine particles may induce asthma in young children.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fine particles may induce hyperactivity in young children.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cleaning helps improve the indoor air quality.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cleaning products may increase the presence of pollutants indoors.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exposure to fine particles may alter the activity of an individual's genes.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Airing your home improves indoor air quality.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Having plants in your home improves indoor air quality.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Question 3: Have you ever wondered about the sources of the fine particles you found in your home? Use the following lines to write about it.

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Question 4: How frequently do you perform these household chores on a scale from never to very often?

	Never	Rarely	Sometimes	Regularly	Often	Very Often
Airing the home	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cleaning the floor (vacuum. mop. etc)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Cleaning the surfaces/ dust	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Question 5: What are the reasons behind the different household chores you perform? Estimate your level of agreement with each proposition.

	Strongly disagree	Disagree	Tend to disagree	Tend to agree	Agree	Strongly agree
Cleanliness/ hygiene	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
To remove dangerous particles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
To remove dust	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
To avoid allergies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Question 6: Consider how you parent your children. Indicate your level of agreement with each statement.

	Strongly disagree	Disagree	Tend to disagree	Tend to agree	Agree	Strongly agree
We have set up rules within the household.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I accept that my children will not follow some rules.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
My children must follow established rules.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Question 7: In general, do you trust:

	Strongly disagree	Disagree	Tend to disagree	Tend to agree	Agree	Strongly agree
The mayor's office of your city	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The state	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The Ministry of National Education	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The industrial companies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Your school	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The media	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Question 8: You are:

- A man
- A woman
- Other:

Question 9: How old are you?

Question 10: Age of your youngest child:

Question 11: Your educational background

- No diploma
- Vocational diploma
- High School Diploma (HSD)
- Advanced technician degree / University diploma of technology / Equivalent HSD +2 years
- Bachelor's degree / Equivalent HSD + 3 years
- Master's degree / Grande Ecole / PhD / Doctorate / Equivalent HSD + 5 years and more
- DNK (do not know)

Question 12: You are

- Farm manager
- Tradesperson / Trader or equivalent / Head of a company with at least 10 employees
- Executive / Higher intellectual profession / Equivalent
- Intermediate profession / Technician / Associate professional / Equivalent
- Employees / Military / Administrative employees / Public officials / Equivalent
- Worker
- Student
- No professional activity

Question 13: ZIP code of the place of residence:



### SI-3 – PAH contents in the three studied preschools

Table SI-3.1: PAH contents (concentration in ng/g), ring distribution, and diagnostic ratios determined in the settled dusts of the suburban preschool (SPS).

Court = courtyard; Play = playground area; n.c. = not calculated. Total index =  $(Ant/(Ant+Phe))/0.1 + Fla/(Fla+Pyr)/0.4 + BaA/(BaA+Chr)/0.2 + IcdP/(IcdP+BghiP)/0.5$ .

<b>Concentration (ng/g)</b>	Suburban preschool (SPS)						
	Indoor			Outdoor			
	Summer	Winter		Summer		Winter	
	Class	Class	Dorm	Court	Play	Court	Play
Nap	48.7	22.6	< LOD	17.3	24.2	64.3	< LOD
Ace	3.0	< LOD	< LOD	5.7	8.5	< LOD	< LOD
Flu	17.9	20.6	< LOD	4.1	4.3	6.5	19.4
Phe	256.7	116.8	68.2	33.8	39.6	99.6	153.2
Ant	< LOD	< LOD	< LOD	28.7	< LOD	< LOD	< LOD
Fla	241.3	88.7	40.6	27.5	57.7	40.9	110.5
Pyr	190.5	101.3	49.6	26.6	100.4	34.7	200.7
B(a)A	220.7	< LOD	< LOD	5.9	14.3	< LOD	< LOD
Chr	127.0	34.5	15.3	15.4	12.9	5.6	17.4
B(b)F	32.2	28.9	12.4	11.6	5.0	5.2	14.3
B(k)F	5.8	6.7	< LOD	3.3	< LOD	0.6	< LOD
B(a)P	12.4	20.4	8.8	6.7	< LOD	2.8	16.7
dB(a,h)A	216.8	< LOD	< LOD	38.5	36.9	< LOD	< LOD
B(ghi)P	43.2	45.0	24.3	11.3	0.7	14.8	27.5
IcdP	141.2	< LOD	< LOD	9.0	35.7	< LOD	< LOD
<i>Sum PAH</i>	1557.4	485.7	219.4	245.5	340.3	275.1	559.9
<i>Sum carcPAH</i>	804.7	113.1	36.6	107.8	129.0	78.5	48.5
<i>%carcPAH</i>	51.7	23.3	16.7	43.9	37.9	28.6	8.7
<b>Ring distribution (%)</b>							
<i>2 rings</i>	4.5	8.9	< 0.4	11.0	10.9	25.6	3.6
<i>3 rings</i>	32.0	42.2	49.0	36.6	28.7	50.8	46.9
<i>4 rings</i>	37.0	35.2	35.1	25.6	38.9	16.7	41.4
<i>5 rings</i>	23.8	4.5	4.6	22.1	21.3	1.5	3.2
<i>6 rings</i>	2.8	9.2	10.9	4.6	0.2	5.3	4.9
<b>Diagnostic ratios</b>							
$\Sigma LMW/\Sigma HMW$	0.27	0.49	0.45	0.58	0.29	1.62	0.46
$Ant/(Ant+Phe)$	0.001	0.002	0.003	0.46	0.005	0.002	0.001
$Fla/(Fla+Pyr)$	0.56	0.47	0.450	0.51	0.37	0.54	0.36
$BaA/(BaA+Chr)$	0.64	0.006	0.013	0.28	0.53	0.036	0.012
$IcdP/(IcdP + BghiP)$	0.77	0.005	0.008	0.44	0.98	0.014	0.008
<i>Total index</i>	6.11	1.22	1.22	8.13	5.53	1.57	0.97

Table SI-3.2: PAH contents (concentration in ng/g), ring distribution, and diagnostic ratios determined in the settled dusts of the urban preschool (UPS).

Court = courtyard; Play = playground area; n.c. = not calculated. Total index =  $(Ant/(Ant+Phe))/0.1 + Fla/(Fla+Pyr)/0.4 + BaA/(BaA+Chr)/0.2 + IcdP/(IcdP+BghiP)/0.5$ .

Concentration (ng/g)	Urban preschool (UPS)							
	Indoor				Outdoor			
	Summer		Winter		Summer		Winter	
	Class	Dorm	Class	Dorm	Court	Play	Court	Play
Nap	164.7	134.9	32.0	201.6	21.9	141.5	13.9	< LOD
Ace	225.3	< LOD	123.1	421.6	9.4	107.5	5.4	2.5
Flu	77.5	60.7	17.3	19.1	11.5	104.0	15.7	9.2
Phe	388.3	352.3	218.5	190.6	97.4	439.9	293.4	191.3
Ant	23.7	27.7	< LOD	< LOD	8.9	75.9	< LOD	< LOD
Fla	289.8	331.8	235.7	260.6	111.7	721.1	328.1	246.3
Pyr	372.6	316.4	271.9	253.5	94.7	651.2	279.6	233.9
B(a)A	853.1	263.7	342.2	157.2	45.8	375.8	173.9	144.0
Chr	302.9	204.9	207.7	153.2	46.6	439.4	157.9	123.6
B(b)F	133.8	136.3	121.1	116.9	49.4	432.0	122.7	118.7
B(k)F	45.7	64.6	37.2	41.0	20.1	177.3	53.8	47.8
B(a)P	74.8	148.5	80.7	96.3	37.5	343.4	84.7	75.2
dB(a,h)A	530.5	270.0	556.2	383.3	23.8	180.4	221.2	278.2
B(ghi)P	341.3	248.3	154.3	157.2	38.9	342.5	151.3	142.0
IcdP	205.6	52.2	243.6	390.3	50.5	475.7	119.5	124.4
<i>Sum PAH</i>	4029.5	2612.4	2641.3	2842.5	668.2	5007.5	2021.1	1737.0
<i>Sum carcPAH</i>	2311.0	1275.1	1620.6	1539.9	295.6	2565.4	947.7	911.9
<i>%carcPAH</i>	57.4	48.8	61.4	54.2	44.2	51.2	46.9	52.5
<b>Ring distribution (%)</b>								
<i>2 rings</i>	11.6	7.5	6.5	22.6	6.4	7.0	1.7	0.7
<i>3 rings</i>	17.4	27.2	17.2	15.9	32.6	24.7	30.8	25.2
<i>4 rings</i>	42.4	37.7	37.1	25.4	38.4	41.5	39.0	38.4
<i>5 rings</i>	20.1	18.0	33.3	30.6	16.7	20.0	21.0	27.5
<i>6 rings</i>	8.5	9.5	5.8	5.5	5.8	6.8	7.5	8.2
<b>Diagnostic ratios</b>								
$\Sigma LMW/\Sigma HMW$	0.2	0.28	0.17	0.42	0.29	0.21	0.19	0.13
$Ant/(Ant+Phe)$	0.058	0.073	0.001	0.001	0.084	0.15	0.001	0.001
$Fla/(Fla+Pyr)$	0.44	0.51	0.46	0.51	0.54	0.53	0.54	0.51
$BaA/(BaA+Chr)$	0.74	0.56	0.62	0.51	0.50	0.46	0.52	0.54
$IcdP/(IcdP + BghiP)$	0.38	0.17	0.61	0.71	0.56	0.58	0.44	0.48
<i>Total Index</i>	6.11	5.17	5.50	5.23	5.80	6.25	4.86	4.91

Table SI-3.3: PAH contents (concentration in ng/g), ring distribution, and diagnostic ratios determined in the settled dusts of the industrial preschool (IPS).

Total index =  $(Ant/(Ant+Phe)/0.1 + Fla/(Fla+Pyr)/0.4 + BaA/(BaA+Chr)/0.2 + IcdP/(IcdP+BghiP)/0.5)$ .

Concentration (ng/g)	Industrial preschool (IPS)			
	Outdoor			
	Summer		Winter	
	Courtyard	Covered Area	Courtyard	Playground
Nap	5.6	17.5	40.1	36.9
Ace	20.1	8.3	15.9	35.2
Flu	21.0	14.2	17.7	42.2
Phe	357.7	199.6	125.9	236.5
Ant	< LOD	< LOD	12.7	19.2
Fla	530.5	276.5	177.4	314.2
Pyr	448.4	259.9	172.1	537.8
B(a)A	341.3	238.9	134.6	236.3
Chr	330.4	161.5	140.8	200.5
B(b)F	352.9	184.0	175.8	136.9
B(k)F	147.6	74.9	62.5	54.2
B(a)P	291.1	145.5	80.9	150.2
dB(a,h)A	59.7	70.5	35.9	145.5
B(ghi)P	281.1	159.6	105.4	169.7
IcdP	228.3	117.4	150.8	90.7
<i>Sum PAH</i>	3415.7	1928.5	1448.3	2406.0
<i>Sum carcPAH</i>	1756.9	1010.3	821.4	1051.3
<i>%carcPAH</i>	51.4	52.4	56.7	43.7
<b>Ring distribution (%)</b>				
<i>2 rings</i>	1.4	2.1	5.1	4.7
<i>3 rings</i>	26.0	24.7	21.8	23.7
<i>4 rings</i>	47.4	47.7	47.3	48.5
<i>5 rings</i>	17.0	17.3	18.5	16.1
<i>6 rings</i>	8.2	8.3	7.3	7.1
<b>Diagnostic ratios</b>				
$\Sigma LMW/\Sigma HMW$	0.134	0.142	0.172	0.182
$Ant/(Ant+Phe)$	0.0005	0.001	0.092	0.075
$Fla/(Fla+Pyr)$	0.542	0.515	0.508	0.369
$BaA/(BaA+Chr)$	0.508	0.597	0.489	0.541
$IcdP/(IcdP + BghiP)$	0.448	0.424	0.589	0.348
<i>Total Index</i>	4.79	5.12	5.81	5.07

Table SI-3.4: Descriptive statistic of the concentrations (in ng/g) for each of the studied PAHs determined in in- and outdoor preschools' settled dusts, including mean, median, min and max values.

PAH	Concentration (ng/g)			
	Min	Max	Median	Mean
Naphtalene	0.4	201.6	24.2	52.1
Acenaphtene	0.2	421.6	8.3	52.2
Fluorene	0.2	104.0	17.7	25.4
Phenanthrene	33.8	439.9	191.3	203.1
Anthracene	0.2	75.9	0.2	10.5
Fluoranthene	27.5	721.1	241.3	233.2
Pyrène	26.6	651.2	233.9	241.9
Benzo(a)anthracene	0.4	853.1	157.2	186.8
Chrysene	5.6	439.4	140.8	142.0
Benzo(b)fluoranthene	5.0	432.0	118.7	115.3
Benzo(k)fluoranthene	0.0	177.3	41.0	44.4
Benzo(a)pyrene	0.0	343.4	75.2	88.3
Dibenzo(ah)anthracene	1.0	556.2	70.5	160.6
Benzo(ghj)perylene	0.7	342.5	142.0	129.4
Indeno(123cd)pyrene	0.4	475.7	117.4	128.2

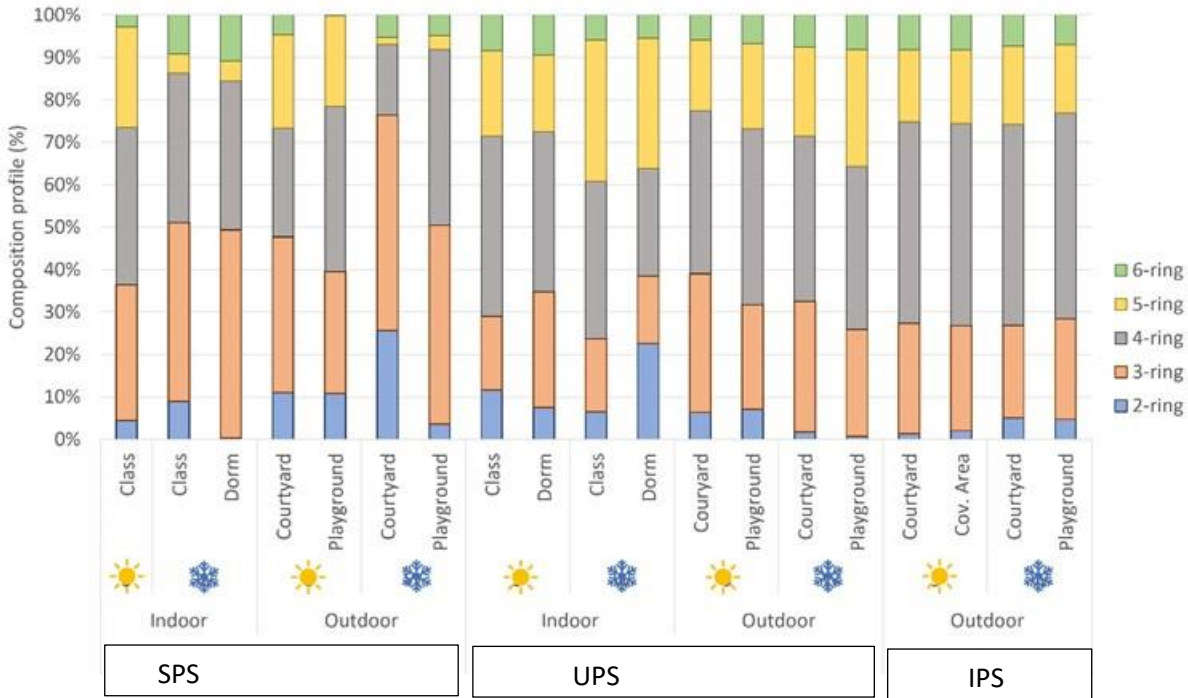


Figure SI-3.5: PAH distribution according to ring number in the different dust samples of the three preschools.

Cov. Area = covered area, SPS=suburban preschool, UPS=urban preschool, IPS=industrial preschool.

Table SI-3.6: Comparison of PAH concentrations (ng/g) in settled dust from different locations and countries.

$\Sigma$ PAH = sum of PAHs;  $\Sigma$ PAH<sub>carc</sub> = sum of carcinogenic PAHs. n.r. = not reported by the authors.

Location	Reference	Number of PAHs		Concentration (ng/g)			
				Min	Max	Median	Mean
<b>Indoor</b>							
Suburban preschool	This study	15	$\Sigma$ PAHs	219	1 557	486	754
		8	$\Sigma$ PAH <sub>carc</sub>	37	805	113	318
Urban preschool		15	$\Sigma$ PAHs	2 612	4 029	2 742	3 031
		8	$\Sigma$ PAH <sub>carc</sub>	1 275	2 311	1 580	1 687
Households, Ottawa, Canada	Maertens <i>et al.</i> , 2008	13	$\Sigma$ PAHs	1 500	325 000	9 530	29 300
		7	$\Sigma$ PAH <sub>carc</sub>	656	219 000	6 060	18 700
Households, Hefei, China	Shen <i>et al.</i> , 2022	16	$\Sigma$ PAHs	7 060	14 540	13 190	11 600
		8	$\Sigma$ PAH <sub>carc</sub>	2 630	6 730	6 300	5 220
Households, Pearl River Delta, China	Kang <i>et al.</i> , 2011	16	$\Sigma$ PAHs	1 630	29 200	4 540	7 310
		7	$\Sigma$ PAH <sub>carc</sub>	350	8 470	1 580	2 380
Indoor dust, Port Harcourt, Nigeria	Ossai <i>et al.</i> , 2021	17	$\Sigma$ PAHs	276	9 128	1 598	2 590
		8	$\Sigma$ PAH <sub>carc</sub>	148	4 618	554	1 139
Households, Vojvodina region, Serbia	Živančev <i>et al.</i> , 2022	16	$\Sigma$ PAHs	140	8 265	1 539	n.r.
		7	$\Sigma$ PAH <sub>carc</sub>	32	1 482	394	n.r.
Preschools, Stockholm, Sweden	Lim <i>et al.</i> , 2021	46	$\Sigma$ PAHs	836	2 540	1 320	1 509
		7	$\Sigma$ PAH <sub>carc</sub>	127	641	319	338
<b>Outdoor</b>							
Suburban preschool, Trets, France	This study	15	$\Sigma$ PAHs	245	560	308	355
		8	$\Sigma$ PAH <sub>carc</sub>	49	129	93	91
Urban preschool, Marseille, France		15	$\Sigma$ PAHs	668	5 007	1 879	2 358
		8	$\Sigma$ PAH <sub>carc</sub>	296	2 565	930	1 180
Industrial preschool, Port Saint Louis du Rhône, France		15	$\Sigma$ PAHs	1 448	3 416	2 167	2 300
		8	$\Sigma$ PAH <sub>carc</sub>	821	1 757	1 031	1 160

Street dust, Novi Sad, Serbia	Škrbić <i>et al.</i> , 2019	16	ΣPAHs	35	2 422	180	430
		7	ΣPAH <sub>carc</sub>	3	1 163	52	123
Street dust, Cairo, Egypt	Hassanien <i>et al.</i> , 2008	12	ΣPAHs	45	2 612	306	704
		6	ΣPAH <sub>carc</sub>	9	113	37	43
Street dust, Port Harcourt, Nigeria	Ossai <i>et al.</i> , 2021	17	ΣPAHs	44	13 168	661	2 488
		8	ΣPAH <sub>carc</sub>	22	6 276	273	1 249
Parking lots dust, USA	Van Metre <i>et al.</i> , 2008	15	ΣPAHs	947	51 089	21 229	21 953
		7	ΣPAH <sub>carc</sub>	376	25 398	9 138	10 581
Street dust, Dhanbad, India	Masto <i>et al.</i> , 2019	13	ΣPAHs	3 980	13 100	7 540	7 417
		7	ΣPAH <sub>carc</sub>	1 194	3 324	2 226	2 315
Street dust, Hefei, China	Shen <i>et al.</i> , 2022	16	ΣPAHs	7 190	9 820	8 870	8 630
		8	ΣPAH <sub>carc</sub>	2 710	6 840	4 610	4 720

#### SI-4 – Metal(loid)s contents in the three studied preschools

Table SI-4.1: Metal(loid)s contents (concentration in µg/g) in the settled dusts of the suburban preschool (SPS).

	Suburban preschool (SPS)						
	Indoor			Outdoor			
	Summer	Winter		Summer		Winter	
	Dorm	Class	Dorm	Courtyard	Playground	Courtyard	Playground
Al	8059.6	8314.2	7778.5	10837.8	16257.0	8913.9	16269.9
As	4.4	4.5	6.3	4.6	13.8	3.9	105.6
Cd	3.0	2.0	2.5	0.5	0.3	0.4	0.7
Co	3.1	1.9	2.4	2.8	3.8	2.0	4.9
Cr	57.5	26.0	40.0	24.3	33.5	17.4	102.0
Cu	179.9	85.9	150.2	29.3	32.9	22.8	175.3
Fe	15320.3	5457.9	17411.3	8552.0	10399.6	6792.8	9302.5
Mn	257.8	164.3	199.2	357.0	342.3	291.6	305.0
Mo	0.9	0.7	1.2	0.5	0.5	0.4	0.7
Ni	16.1	28.3	51.6	12.0	16.7	8.8	85.5
Pb	43.9	31.5	33.8	30.6	18.0	19.7	25.9
Sb	61.6	3.1	117.2	1.0	1.0	0.9	1.7
Th	3.1	1.9	2.6	6.8	5.8	3.9	4.6
Ti	744.7	318.4	558.1	437.4	452.6	401.5	885.8
U	0.7	0.5	0.7	1.2	0.9	0.8	0.8
V	12.8	12.6	12.3	18.7	22.5	17.4	23.4
Zn	1130.8	700.7	1126.3	476.9	467.0	469.9	460.5
<i>Sum MM</i>	25900.0	15154.4	27494.3	20793.4	28068.4	16967.9	27754.9
<i>Sum carcMM</i>	206.1	112.3	269.4	102.5	116.4	75.1	355.1
<i>%carcMM</i>	0.8	0.7	1.0	0.5	0.4	0.4	1.3

Table SI-4.2: Metal(loid)s contents (concentration in µg/g) in the settled dusts of the urban preschool (UPS).

	Urban preschool (UPS)						
	Indoor			Outdoor			
	Summer		Winter	Summer		Winter	
	Classroom	Dormitory	Classroom	Courtyard	Playground	Courtyard	Playground
Al	18798.8	22509.2	13557.7	40183.2	35302.9	21806.8	29865.4
As	7.4	6.8	7.4	7.9	10.2	5.7	6.6
Cd	2.3	1.9	1.2	1.0	1.4	1.0	1.4
Co	4.9	4.8	3.8	5.2	7.3	5.3	5.9
Cr	72.6	78.2	66.5	72.9	64.7	45.6	53.7
Cu	341.0	362.6	279.6	224.7	266.5	162.3	193.2
Fe	13004.4	13401.2	11643.2	15047.2	15362.7	10141.0	12108.9
Mn	247.8	218.7	161.5	272.4	319.8	202.6	242.4
Mo	4.7	4.2	5.5	4.0	5.6	2.6	3.1
Ni	54.7	45.6	38.7	29.3	32.1	20.1	23.0
Pb	218.9	145.3	167.6	166.0	192.2	102.8	116.2
Sb	14.3	31.0	13.9	7.8	10.8	6.7	8.7
Th	2.4	1.8	2.0	2.8	2.6	1.9	2.5
Ti	700.8	982.9	672.5	497.4	687.9	470.6	697.5
U	1.1	0.9	0.8	1.3	1.4	0.9	1.1
V	21.7	19.9	15.0	26.9	29.6	19.2	27.4
Zn	3003.1	6031.1	2752.1	1080.7	1540.4	961.6	1631.8
<i>Sum MM</i>	36500.9	43846.3	29389.0	57630.6	53838.0	33956.8	44988.6
<i>Sum carcMM</i>	400.3	336.2	317.0	321.0	352.2	209.3	246.4
<i>%carcMM</i>	1.1	0.8	1.1	0.6	0.7	0.6	0.5

Table SI-4.3: Metal(loid)s contents (concentration in  $\mu\text{g/g}$ ) in the settled dusts of the industrial preschool (IPS).

	Industrial preschool (IPS)			
	Outdoor			
	Summer		Winter	
	Courtyard	Covered area	Courtyard	Playground
Al	14160.1	11341.2	15215.0	13153.4
As	5.9	13.0	7.3	10.8
Cd	0.8	0.8	0.7	0.9
Co	5.7	4.6	5.3	5.4
Cr	87.3	83.5	104.4	166.9
Cu	49.2	242.6	45.1	154.4
Fe	24735.8	15628.5	31036.2	18598.9
Mn	517.7	384.8	589.3	448.0
Mo	3.6	3.2	3.0	3.3
Ni	23.4	26.4	26.8	20.8
Pb	118.8	116.7	151.3	181.1
Sb	3.5	3.5	3.0	4.0
Th	2.6	2.1	5.1	2.9
Ti	550.3	430.6	599.2	535.1
U	0.8	0.7	1.2	1.0
V	31.2	24.3	35.1	31.7
Zn	1086.5	4253.2	829.8	1986.0
<i>Sum MM</i>	41383.1	32559.8	48720.4	35242.1
<i>Sum carcMM</i>	279.9	275.6	402.8	363.0
<i>%carcMM</i>	0.7	0.8	0.8	1.0

Table SI-4.4: Descriptive statistic of the concentrations (in  $\mu\text{g/g}$ ) for each of the studied elements determined in in- and out-door preschools' settled dusts, including mean, median, min and max values.

Metal(loid)s	Concentration ( $\mu\text{g/g}$ )			
	Min	Max	Median	Mean

Al	7778.5	40183.2	14687.6	17351.4
As	3.9	105.6	7.0	12.9
Cd	0.3	3.0	1.0	1.3
Co	1.9	7.3	4.8	4.4
Cr	17.4	166.9	65.6	66.5
Cu	22.8	362.6	168.8	166.5
Fe	5457.9	31036.2	13202.8	14108.0
Mn	161.5	589.3	282.0	306.8
Mo	0.4	5.6	3.0	2.6
Ni	8.8	85.5	26.6	31.1
Pb	18.0	218.9	116.5	104.5
Sb	0.9	117.2	5.3	16.3
Th	1.8	6.8	2.6	3.2
Ti	318.4	982.9	554.2	590.2
U	0.5	1.4	0.9	0.9
V	12.3	35.1	22.1	22.3
Zn	460.5	6031.1	1106.4	1666.0

Table SI-4.5: Comparison of metallic concentration ( $\mu\text{g/g}$ ) in settled dust from different locations and countries.

$\Sigma\text{MM}$  = sum of metals and metalloids;  $\Sigma\text{MM}_{\text{carc}}$  = sum of carcinogenic metals and metalloids. <sup>a</sup> = 25<sup>th</sup> percentile; <sup>b</sup> = 75<sup>th</sup> percentile. n.r. = not reported by authors.

Location	Reference	Number of MMs		Concentration ( $\mu\text{g/g}$ )			
				Min	Max	Median	Mean
<b>Indoor</b>							
Suburban preschool, Trets, France	This study	17	$\Sigma\text{MMs}$	15 154	27 494	25 900	22 850
		10	$\Sigma\text{MM}_{\text{carc}}$	112	269	206	196
Urban preschool, Marseille, France		17	$\Sigma\text{MMs}$	29 389	43 846	36 501	36 579
		10	$\Sigma\text{MM}_{\text{carc}}$	317	400	336	351
Households, Ottawa, Canada	Rasmussen <i>et al.</i> , 2001	30	$\Sigma\text{MMs}$	32 395	143 736	58 853	64 243
		8	$\Sigma\text{MM}_{\text{carc}}$	120	4 039	388	611
Schools and households, Hunan Province, China	Cao <i>et al.</i> , 2016	12	$\Sigma\text{MMs}$	539 <sup>a</sup>	2336 <sup>b</sup>	1 345	n.r.
		8	$\Sigma\text{MM}_{\text{carc}}$	166 <sup>a</sup>	769 <sup>b</sup>	435	n.r.
Nursery schools, Xi'an, China	Lu <i>et al.</i> , 2014	9	$\Sigma\text{MMs}$	1 457	6 570	2 316	1 532
		5	$\Sigma\text{MM}_{\text{carc}}$	367	1 602	225	430
Nursery schools, Shah Alam, Malaysia	Darus <i>et al.</i> , 2012	8	$\Sigma\text{MMs}$	2 550	9 870	5 347	5 722
		3	$\Sigma\text{MM}_{\text{carc}}$	31	102	51	57
Classrooms, Ilaro, Nigeria	Olujimi <i>et al.</i> , 2015	46	$\Sigma\text{MMs}$	5 544	51 255	10 840	16 491
		9	$\Sigma\text{MM}_{\text{carc}}$	120	9 375	483	996
Households, Estarreja, Portugal	Plumejeaud <i>et al.</i> , 2016	16	$\Sigma\text{MMs}$	10 963	18 395	13 523	14 764
		8	$\Sigma\text{MM}_{\text{carc}}$	265	1 354	385	559
<b>Outdoor</b>							
Suburban preschool, Trets, France	This study	17	$\Sigma\text{MMs}$	16 968	28 068	24 274	23 396
		10	$\Sigma\text{MM}_{\text{carc}}$	75	355	109	162
Urban preschool, Marseille, France		17	$\Sigma\text{MMs}$	33 957	57 631	49 413	47 604
		10	$\Sigma\text{MM}_{\text{carc}}$	209	352	284	282
Industrial preschool, Port Saint Louis du Rhône, France		17	$\Sigma\text{MMs}$	32 560	48 720	38 313	39 476
		10	$\Sigma\text{MM}_{\text{carc}}$	276	403	321	330

Kindergarten soil, Yerevan, Armenia	Tepanosyan <i>et al.</i> , 2017	16	$\Sigma$ MMs	31 692	58 198	44 375	44 525
		7	$\Sigma$ MM <sub>carc</sub>	125	440	210	215
Street dust, Ottawa, Canada	Rasmussen <i>et al.</i> , 2001	30	$\Sigma$ MMs	30 087	145 511	98 042	99 540
		8	$\Sigma$ MM <sub>carc</sub>	36	188	102	104
Highway dust, Toronto, Canada	Nazzal <i>et al.</i> , 2012	11	$\Sigma$ MMs	17 931	453 719	188 752	188 752
		4	$\Sigma$ MM <sub>carc</sub>	106	1 265	440	440
Street dust, Dhanbad, India	Masto <i>et al.</i> , 2019	9	$\Sigma$ MMs	640	1 152	833	840
		6	$\Sigma$ MM <sub>carc</sub>	218	349	271	271
Street dust, Novi Sad, Serbia	Škrbić <i>et al.</i> , 2018	7	$\Sigma$ MMs	14	1 299	104	104
		6	$\Sigma$ MM <sub>carc</sub>	12	927	74	74

## SI-5 – Source apportionment

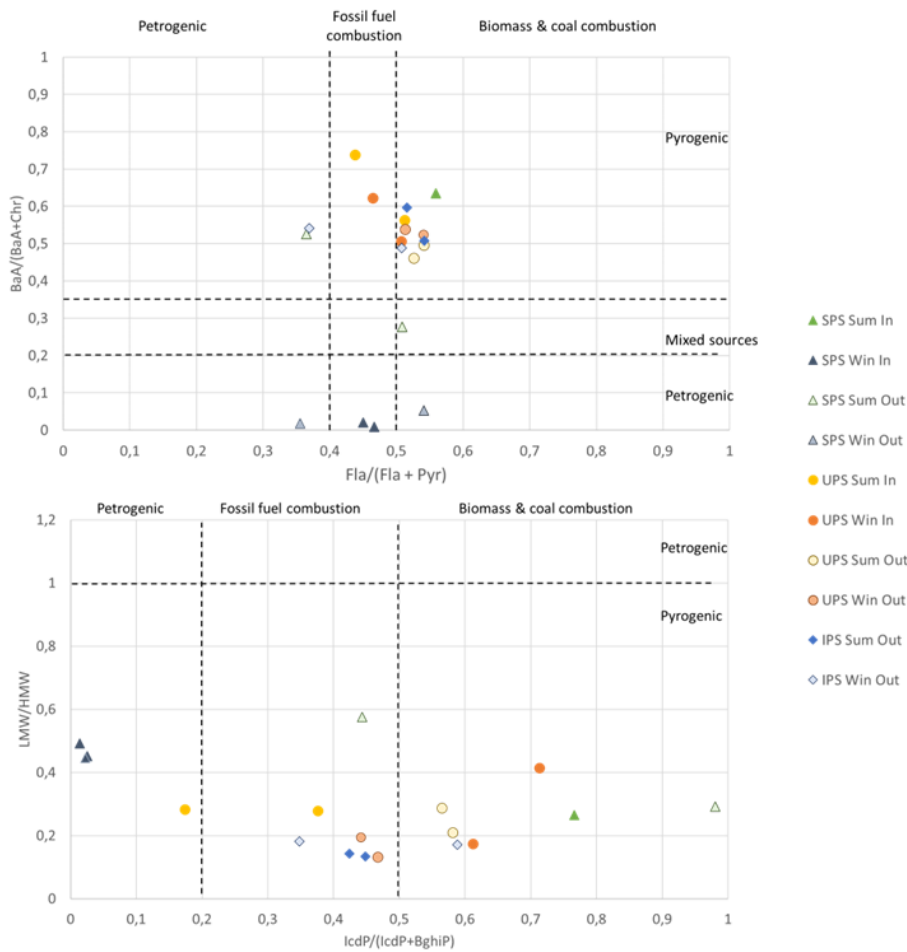
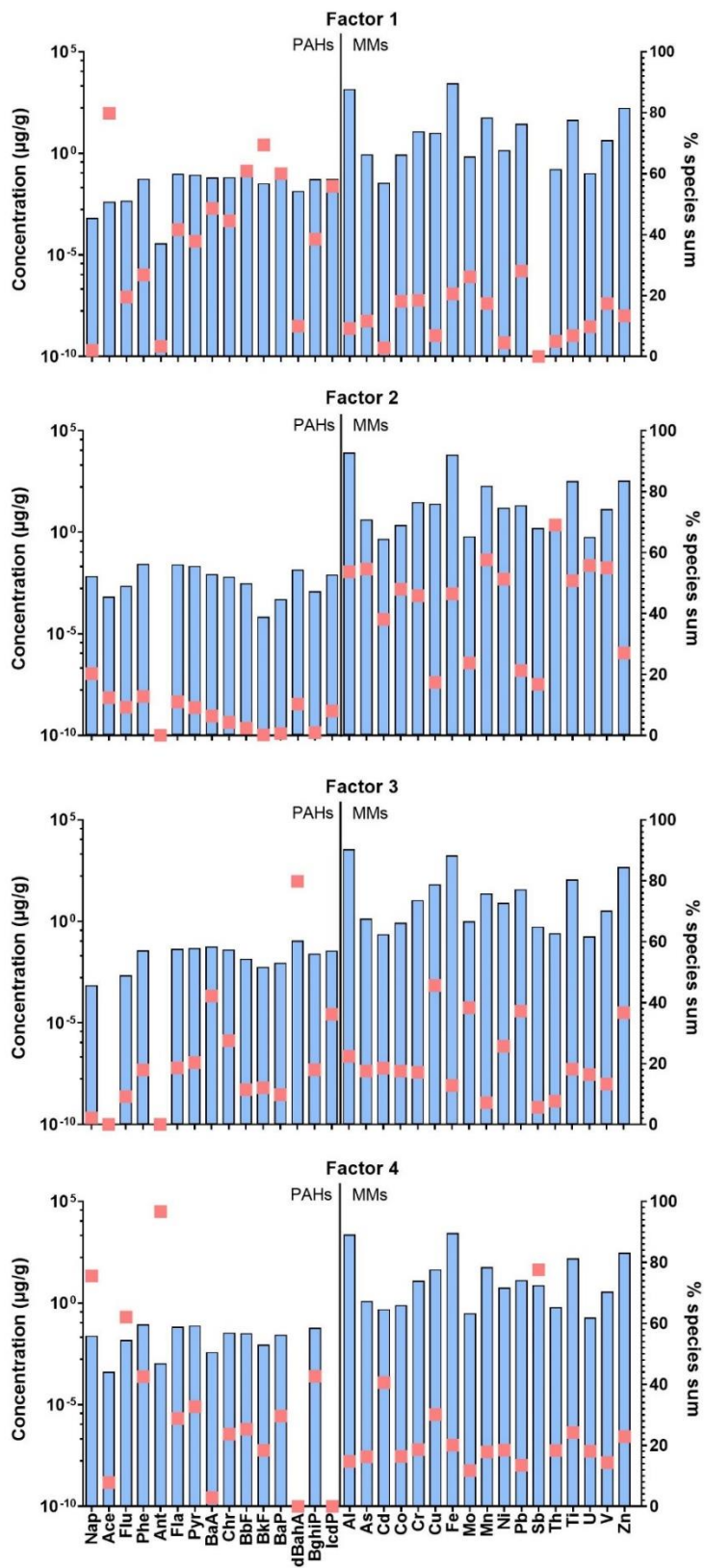


Figure SI-5.1: PAHs source analysis based on diagnostic ratios. Plot of  $BaA/(BaA+Chr)$  vs  $Fla/(Fla+Pyr)$  (top) and  $IcdP/(IcdP+BghiP)$  vs  $LMW/HMW$  ratios (bottom).

$Fla/(Fla+Pyr)$  = fluoranthene / (fluoranthene + pyrene);  $BaA/(BaA+Chr)$  = benz(a)anthracene / (benz(a)anthracene + chrysene);  $IcdP/(IcdP+BghiP)$  = indeno(1.2.3-c.d)pyrene / (benzo(g,h,i)perylene + indeno(1.2.3-c.d)pyrene);  $LMW/HMW$  = Low Molecular Weight PAHs / High Molecular Weight PAHs=2-3 ring PAHs/4-6 ring PAHs. SPS = suburban preschool; UPS = urban preschool; IPS = industrial preschool; Sum = summer; Win = winter; In = indoor; Out = outdoor.

Figure SI-5.2: PMF factor profiles with the concentration on the left axis (blue bars) and with % of species sum on the right axis (red square) against PAHs and MMs determined in settled dust.



## SI-6 – Risk assessment

Table SI-6.1: Non cancer risk and cancer risk assessments for each sampling location collected in suburban (SPS), urban (UPS) and industrial (IPS) preschools.

Calculated hazard index (HI) taking into account the sum of the carcinogenic MMs ( $\Sigma MM_{\text{carc}}$  HI); the sum of all the MMs ( $\Sigma MM$  HI); n.c. for not calculated. The risk limits are set at 1 for HI and 1.00E-04 for ILCR. Calculated incremental life cancer risk (ILCR) taking into account the metal(loid)s (MM ILCR), the polycyclic aromatic hydrocarbons (ILCR PAH) and both MMs and PAHs ( $\Sigma ILCR$  = sum of the MM ILCR plus the PAH ILCR).

Sampling locations		Season	$\Sigma PAH$ HI	$\Sigma MM_{\text{carc}}$ HI	$\Sigma MM$ HI	MM ILCR	PAH ILCR	$\Sigma ILCR$	
SPS	Indoor	Summer	Classroom	1.89E-09	n.c.	n.c.	n.c.	1.75E-06	1.75E-06
			Dorm	n.c.	0.43	0.50	4.29E-05	n.c.	4.29E-05
		Winter	Classroom	1.75E-10	0.11	0.15	3.36E-05	1.62E-07	3.37E-05
			Dorm	7.41E-11	0.70	0.78	5.45E-05	6.84E-08	5.46E-05
	Outdoor	Summer	Courtyard	3.40E-10	0.08	0.14	2.48E-05	3.14E-07	2.51E-05
			Playground	2.98E-10	0.15	0.22	4.51E-05	2.75E-07	4.54E-05
		Winter	Courtyard	2.68E-11	0.07	0.11	1.87E-05	2.48E-08	1.87E-05
			Playground	1.33E-10	0.77	0.85	2.48E-04	1.23E-07	2.48E-04
UPS	Indoor	Summer	Classroom	5.13E-09	0.22	0.34	7.51E-05	4.74E-06	7.98E-05
			Dorm	3.31E-09	0.29	0.43	7.19E-05	3.06E-06	7.50E-05
		Winter	Classroom	4.98E-09	0.18	0.28	6.39E-05	4.60E-06	6.85E-05
			Dorm	3.86E-09	n.c.	n.c.	n.c.	3.56E-06	3.56E-06
	Outdoor	Summer	Courtyard	5.51E-10	0.17	0.32	6.31E-05	5.09E-07	6.36E-05
			Playground	4.74E-09	0.22	0.37	6.41E-05	4.37E-06	6.85E-05
		Winter	Courtyard	2.48E-09	0.14	0.23	4.14E-05	2.29E-06	4.37E-05
			Playground	2.79E-09	0.18	0.29	4.82E-05	2.57E-06	5.08E-05
IPS	Outdoor	Summer	Courtyard	3.24E-09	0.13	0.25	6.40E-05	2.99E-06	6.69E-05
			Covered courtyard	1.96E-09	0.17	0.28	7.39E-05	1.81E-06	7.57E-05
		Winter	Courtyard	1.20E-09	0.14	0.27	7.88E-05	2.27E-06	8.11E-05
			Playground	2.45E-09	0.17	0.27	1.07E-04	1.11E-06	1.08E-04

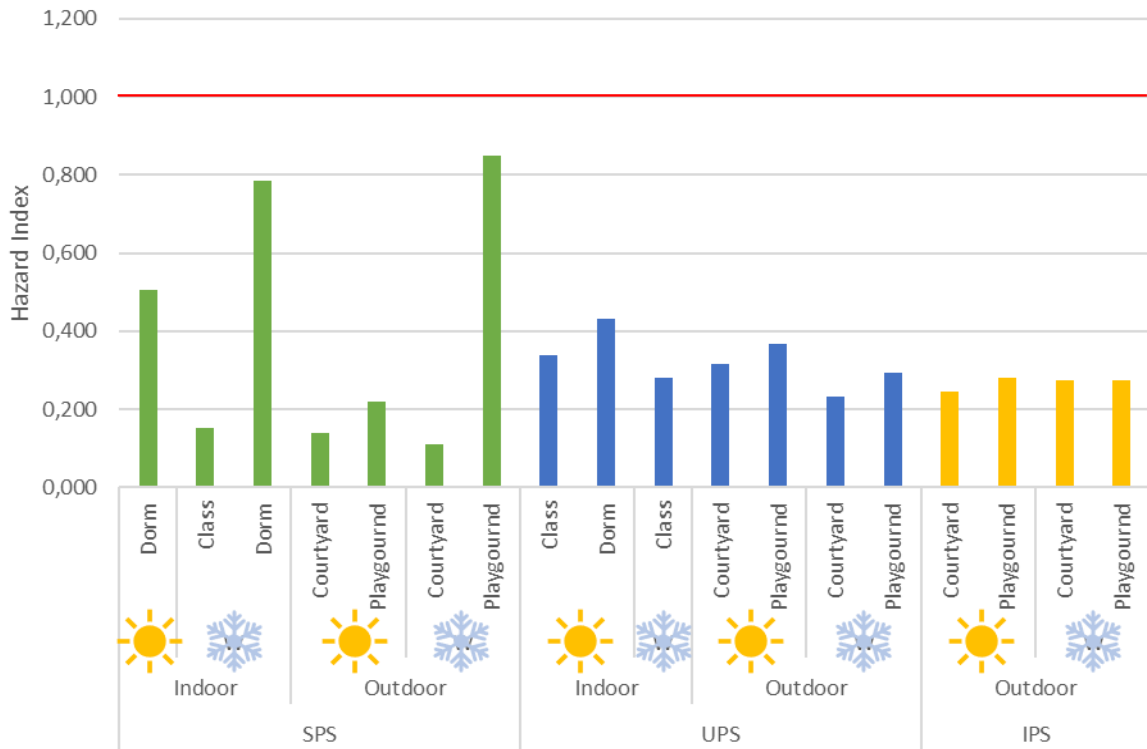


Figure SI-6.2 Non cancer risk assessment for each sampling location collected in suburban (SPS), urban (UPS) and industrial (IPS) preschools. Red line = unacceptable risk limit.

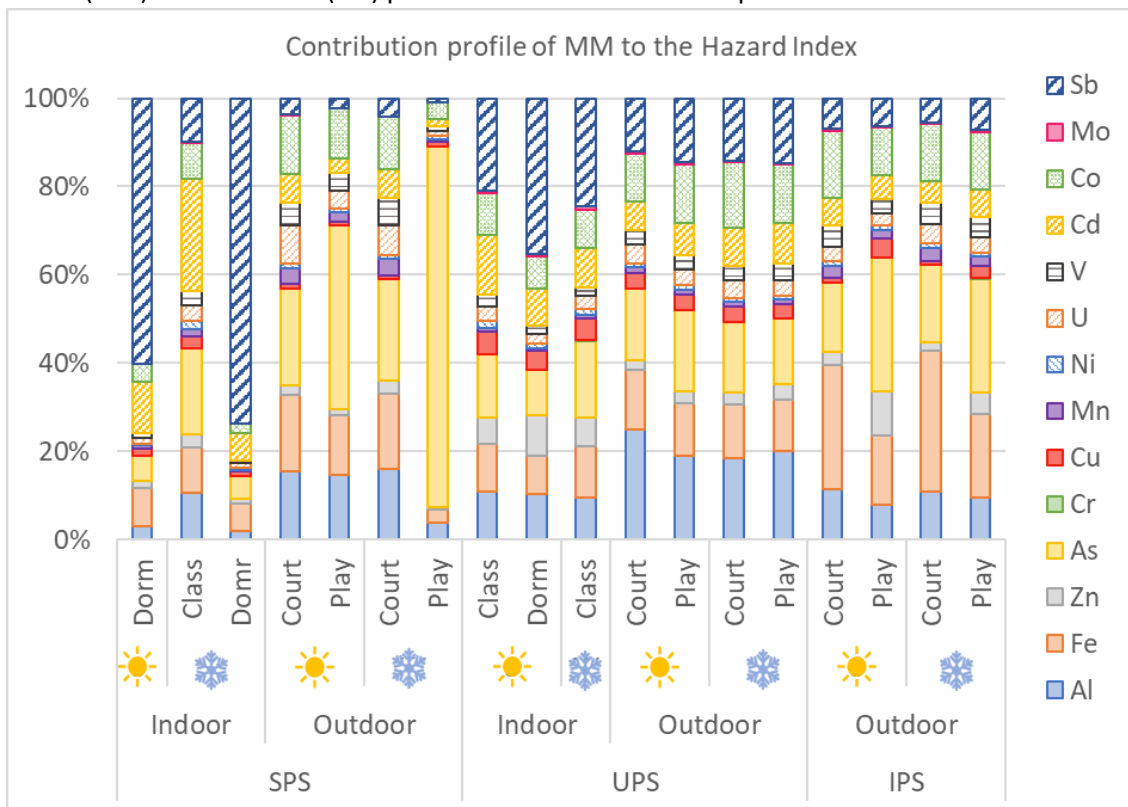


Figure SI-6.3: Contribution profiles of MMs to the hazard index in each sampling location collected in suburban (SPS), urban (UPS) and industrial (IPS) preschools.

Table SI-6.4: Non carcinogenic risk assessment at the studied preschools and comparison with data obtained elsewhere.  $\Sigma MM_{carc}$  = sum of the carcinogenic metal(loid)s;  $\Sigma MM$  = sum of all the metal(loid)s; HI = hazard index. a = authors only indicated one value. n.r. = not reported by authors. Extracted data included the oral risk assessments only. Values exceeding the risk limit of 1 are indicated in bold.

Location	Reference	Number of MMs considered and calculated HI		Min	Max	Median	Mean
<i>Indoor</i>							
Suburban preschool, Trets, France	This study	14	$\Sigma MM$ HI	0.15	0.78	0.50	0.48
		8	$\Sigma MM_{carc}$ HI	0.11	0.70	0.43	0.41
Urban preschool, Marseille, France		14	$\Sigma MM$ HI	0.00	0.43	0.31	0.26
		8	$\Sigma MM_{carc}$ HI	0.00	0.29	0.20	0.17
Schools and households, Hunan Province, China	Cao <i>et al.</i> , 2016	12	$\Sigma MM$ HI	<b>21.28</b>	<b>32.03</b>	<b>25.55</b>	n.r.
		8	$\Sigma MM_{carc}$ HI	<b>16.51</b>	<b>24.57</b>	<b>19.74</b>	n.r.
Nursery schools, Xi'an, China	Lu <i>et al.</i> , 2014	9	$\Sigma MM$ HI	n.r.	n.r.	n.r.	<b>1.41<sup>a</sup></b>
		5	$\Sigma MM_{carc}$ HI	n.r.	n.r.	n.r.	<b>1.19<sup>a</sup></b>
Classrooms, Ilaro, Nigeria	Olujimi <i>et al.</i> , 2015	11	$\Sigma MM$ HI	n.r.	n.r.	n.r.	0.25 <sup>a</sup>
		6	$\Sigma MM_{carc}$ HI	n.r.	n.r.	n.r.	0.22 <sup>a</sup>
<i>Outdoor</i>							
Suburban preschool, Trets, France	This study	14	$\Sigma MM$ HI	0.11	0.85	0.18	0.33
		8	$\Sigma MM_{carc}$ HI	0.08	0.70	0.12	0.27
Urban preschool, Marseille, France		14	$\Sigma MM$ HI	0.23	0.37	0.31	0.30
		8	$\Sigma MM_{carc}$ HI	0.14	0.22	0.17	0.18
Industrial preschool, Port Saint Louis du Rhône, France		14	$\Sigma MM$ HI	0.25	0.28	0.27	0.27
		8	$\Sigma MM_{carc}$ HI	0.13	0.17	0.15	0.15
Street dust, Mexico City, Mexico	Aguilera <i>et al.</i> , 2021	9	$\Sigma MM$ HI	0.15	<b>10.80</b>	0.80	0.96
		5	$\Sigma MM_{carc}$ HI	0.11	<b>9.78</b>	0.68	0.82
Street dust, Murcia, Spain	Gabarron <i>et al.</i> , 2017	7	$\Sigma MM$ HI	0.55	<b>1.04</b>	0.76	0.78
		5	$\Sigma MM_{carc}$ HI	0.11	0.22	0.14	0.16
Street dust, Novi Sad, Serbia	Škrbić <i>et al.</i> , 2018	7	$\Sigma MM$ HI	0.54	<b>1.54</b>	<b>1.03</b>	<b>1.04</b>
		6	$\Sigma MM_{carc}$ HI	0.52	<b>1.53</b>	<b>1.01</b>	<b>1.02</b>

Table SI-6.5: Carcinogenic risk assessment at the studied preschools and comparison with data obtained elsewhere. ILCR = incremental life cancer risk and indication in the left-hand column of the number of carcinogenics including in the calculation; MM ILCR= incremental life cancer risk due to carcinogenic metal(loid)s, PAH ILCR= incremental life cancer risk due to polycyclic aromatic hydrocarbons,  $\Sigma$ ILCR = sum of the MM ILCR plus the PAH ILCR; n.r. = not reported by authors. Extracted data included the oral risk assessments only. Values exceeding the risk limit of 1E-04 are indicated in bold.

Location	Reference	Number of carcinogenic compounds considered and calculated ILCR		Min	Max	Median	Mean
<i>Indoor</i>							
Suburban preschool, Trets, France	This study	18	$\Sigma$ ILCR	1.75E-06	5.46E-05	3.83E-05	3.32E-05
		3	MM ILCR	3.36E-05	5.45E-05	4.29E-05	4.36E-05
		15	PAH ILCR	6.84E-08	1.75E-06	1.62E-07	6.59E-07
Urban preschool, Marseille, France		18	$\Sigma$ ILCR	3.56E-06	7.98E-05	7.17E-05	5.67E-05
		3	MM ILCR	0.00E+00	7.51E-05	6.79E-05	5.27E-05
		15	PAH ILCR	3.06E-06	4.74E-06	4.08E-06	3.99E-06
Households, Hefei, China	Shen <i>et al.</i> , 2022	16	PAH ILCR	n.r.	n.r.	n.r.	1.80E-05
Nursery schools, Xi'an, China	Lu <i>et al.</i> , 2014	3	MM ILCR	n.r.	n.r.	n.r.	6.62E-08
Households, Vojvodina region, Serbia	Živančev <i>et al.</i> , 2022	16	PAH ILCR	6.76E-06	<b>7.86E-04</b>	<b>1.30E-04</b>	n.r.
Households, Houston Metropolitan Area, USA	Davis <i>et al.</i> , 2021	4	MM ILCR	<b>5.02E-04</b>	<b>8.56E-04</b>	<b>5.53E-04</b>	<b>6.16E-04</b>
<i>Outdoor</i>							
Suburban preschool, Trets, France	This study	18	$\Sigma$ ILCR	1.87E-05	2.48E-04	3.53E-05	8.42E-05
		3	MM ILCR	1.87E-05	2.48E-04	3.50E-05	8.40E-05
		15	PAH ILCR	2.48E-08	3.14E-07	1.99E-07	1.84E-07
Urban preschool, Marseille, France		18	$\Sigma$ ILCR	4.37E-05	6.85E-05	5.72E-05	5.66E-05
		3	MM ILCR	4.14E-05	6.41E-05	5.56E-05	5.42E-05
		15	PAH ILCR	5.09E-07	4.37E-06	2.43E-06	2.44E-06
Industrial preschool, Port Saint Louis du Rhône, France		18	$\Sigma$ ILCR	6.69E-05	<b>1.08E-04</b>	7.84E-05	8.29E-05
		3	MM ILCR	6.40E-05	1.07E-04	7.64E-05	8.09E-05
		15	PAH ILCR	1.11E-06	2.99E-06	2.04E-06	2.04E-06
Kindergarten soil, Yerevan, Armenia	Tepanosyan <i>et al.</i> , 2017	2	MM ILCR	1.33E-06	3.82E-06	n.r.	2.44E-06

Street dust, Rio de Janeiro State, Brazil	Franco <i>et al.</i> , 2017	15	PAH ILCR	7.51E-09	1.80E-06	4.04E-07	5.44E-07
Street dust, Hefei, China	Shen <i>et al.</i> , 2022	16	PAH ILCR	n.r.	n.r.	n.r.	1.12E-05
Street dust, Novi Sad, Serbia	Škrbić <i>et al.</i> , 2019	16	PAH ILCR	2.83E-06	<b>6.06E-04</b>	2.38E-05	6.06E-05
Street dust, Murcia, Spain	Gabarron <i>et al.</i> , 2017	4	MM ILCR	2.06E-08	4.60E-08	3.55E-08	3.40E-08

1 **SI-7: Parental knowledge, perception, and prevention behavior from dust threat to children**

2 Table SI-7-1: Descriptive statistics of questionnaire items composing the variables used in the  
 3 regression analysis.

4

Variable	Mean	SD
<b>Cleaning behaviour [composite variable, six-point scale (1) never to (5) always] (<math>\alpha</math> de Cronbach = .68)</b>		
1. Ventilate the house	5.41	1.00
2. Clean the floor (vacuum, mop, broom, <i>etc.</i> )	4.67	1.09
3. Clean surfaces / dust	3.89	1.16
<b>Settled dust knowledge [composite variable, six-point scale (1) totally disagree to (5) totally agree] (<math>\alpha</math> de Cronbach = .63)</b>		
1. Settled dust can contain pollutants.	5.33	.81
2. Settled dust can cause asthma in young children.	5.31	.82
3. Settled dust can cause hyperactivity in young children.	3.63	1.08
4. Cleaning helps you improve indoor air quality.	4.07	1.23
5. Household products can increase the presence of pollutants inside buildings.	5.11	1.02
6. Exposure to settled dust can lead to changes in the activity of an individual's genes.	4.19	1.16
7. Exposure to pollutants can lead to genetic changes.	4.10	1.17
8. Ventilating your home improves indoor air quality.	5.03	.98
9. Owning plants inside your home allows you to improve indoor air quality.	4.65	1.10
<b>Settled dust risk perception [composite variable, six-point scale (1) totally disagree to (5) totally agree] (<math>\alpha</math> de Cronbach = .77)</b>		
1. When at home, do you think your child is exposed to settled dust?	4.31	1.13
2. When outdoors, do you think your child is exposed to settled dust?	5.08	.97
3. When at school, do you think your child is exposed to settled dust?	4.58	1.03
<b>Rule-setting parental style [composite variable, six-point scale (1) totally disagree to (5) totally agree] (Pearson's <math>r = .35</math>. <math>p &lt; .001</math>)</b>		
1. We have set up rules within the household.	5.2	2.13
2. My child must follow the rules to the letter.	3.31	1.5

5

6

7 Table SI-7.2: Regression model of 'household cleaning behavior' (outcome variable).

8

Predictors	Adj R <sup>2</sup>	F	df	Beta	t	LLCI	ULCI
	.14	7.87***	5.162				
Parent gender (female) <sup>1</sup>				.51	.70	-.255	.538
Age of youngest child				.04	.64	-.027	.052
Settled dust knowledge				.01	.05	-.006	.007
Settled dust risk perception				.14	1.9	-.008	.298
Parental style (rule oriented) <sup>2</sup>				.40	5.66***	.107	.222

9 \*  $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$

- 10
- 11 1. Parent gender is a dummy variable [0= male; 1=female]. The predictive variable corresponds
- 12 therefore to the fact that the parent is female in relation to male.
- 13 2. Parental style is a composite variable of two levels of rule-setting parental styles: "We have
- 14 set up rules within the household" and "My child must follow established rules".
- 15
- 16
- 17

18 Table SI-7.3: Correlation analysis between variables entered in the regression analysis.

19

	Cleaning behaviour	Settled dust knowledge	Settled dust risk perception	Parental style
Cleaning behaviour	1	.05	.07	.30**
Settled dust knowledge	.05	1	.29**	.06
Settled dust risk perception	.07	.29**	1	-.15*
Parental style (rule setting)	.30**	.06	.15*	1

20 \*  $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$

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