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LISTE INDICATIVE DES EXPERTS DU RESEAU POUR CHAQUE THEMATIQUE

NB : Cette liste n'est qu'indicative et ne prétend pas à l'exhaustivité des domaines couverts par chacun.

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I. MÉTROLOGIE (PROTOCOLES PRELEVEMENTS / ANALYSES / MODELISATION)

I.1 Gaz inorganiques / métaux

Rubrique N°1

a. Radon

1. **C. Sainz-Fernandez, A. Fernandez-Villar, I. Fuente-Merino, J. L. Gutierrez-Villanueva, J. L. Martin-Matarranz, M. Garcia-Talavera, S. Casal-Ordas and L. S. Quindos-Poncela**, **THE SPANISH INDOOR RADON MAPPING STRATEGY** (**2014**), Journal/Radiation Protection Dosimetry, 162, 58-62.

Indoor radon mapping still represents a valuable tool for drawing the picture of the exposure of general public due to radon and radon progeny inhalation in a residential context. The information provided by means of a map is useful not only as awareness and strategic element for authorities and policy-makers, but also as a scientific start-up point in the design of epidemiological and other specific studies on exposure to natural radiation. The requirements for a good mapping are related to harmonisation criteria coming from European recommendations, as well as to national/local characteristics and necessities. Around 12 000 indoor radon measurements have been made since the Spanish national radon programme began at the end of the 1980s. A significant proportion of them resulted from the last campaign performed from 2009 to 12. This campaign completed the first version of a map based on a grid 10 x 10 km(2). In this paper, the authors present the main results of a new map together with the criteria adopted to improve the number of measurements and the statistical significance of them.

2. **R. Trevisi, F. Cardellini, F. Leonardi, C. V. Trassierra and D. Franci**, **A COMPARISON OF RADON AND ITS DECAY PRODUCTS' BEHAVIOUR IN INDOOR AIR** (**2014**), Journal/Radiation Protection Dosimetry, 162, 171-175.

The inhalation of short-lived radon decay products (RDP) yields the greatest contribution to the natural radiation exposure. This paper deals with a study carried out to improve the knowledge of the behaviour of RDPs, their interaction with particulates and the plateout during the time. The tests confirmed that a high aerosol particle concentration increases the probability that an ion sticks to aerosol and remains long in the air, leading to both an increase of F and a decrease of f(p), as reported in the literature. The same experimental protocol applied in a small radon chamber showed a strong reduction of the equilibrium factor (an average of similar to 10 %), because in a small environment the plateout phenomenon prevails on the attachment to particulate.

b. Métaux

Pas d'article

I.2 Composés Organiques Volatils, COSemi-Volatils

Rubrique N°2

a.   COV / Aldéhydes

3. **J. Faber, K. Brodzik, A. Golda-Kopek, D. Lomankiewicz, J. Nowak and A. Swiatek**, **Passive sampling application to control air quality in interior of new vehicles** (**2015**), Journal/Chemical Papers, 69, 799-809.

The investigation of air pollution is a highly important field of research. Air quality in a vehicle's interior has attracted growing attention since people spend much of their time in vehicles and those frequently travelling in new cars are exposed to harmful compounds. The main air pollutants inside new vehicles are volatile organic compounds (VOCs), present as a result of interior materials' de-gassing. Among the sampling methods used in indoor air quality research, active sampling for VOCs collection is one method that has been extensively described and applied. The present study sought to implement passive sampling with Radiello (R) samplers to collect air samples directly in the car factory. The results from passive sampling were compared with results derived from active sampling using Carbograph 1TD and silicagel coated with 2,4-dinitrophenylhydrazine cartridges, based on previously validated methods. The identification and quantification of organic compounds was performed using gas chromatography with flame ionisation coupled with a mass spectrometer after thermal desorption. Aldehydes were determined by means of high-performance liquid chromatography. In the present study, the results obtained with the use of active and passive methods of air sampling were compared, correlations between the two sampling methods were designated and the repeatability of passive sampling was detailed. (C) 2015 Institute of Chemistry, Slovak Academy of Sciences

4. **T. A. Wetzel and W. J. Doucette**, **Plant leaves as indoor air passive samplers for volatile organic compounds (VOCs)** (**2015**), Journal/Chemosphere, 122, 32-37.

Volatile organic compounds (VOCs) enter indoor environments through internal and external sources. Indoor air concentrations of VOCs vary greatly but are generally higher than outdoors. Plants have been promoted as indoor air purifiers for decades, but reports of their effectiveness differ. However, while air-purifying applications may be questionable, the waxy cuticle coating on leaves may provide a simple, cost-effective approach to sampling indoor air for VOCs. To investigate the potential use of plants as indoor air VOC samplers, a static headspace approach was used to examine the relationship between leaf and air concentrations, leaf lipid contents and octanol-air partition coefficients (Koa) for six VOCs and four plant species. The relationship between leaf and air concentrations was further examined in an actual residence after the introduction of several chlorinated VOC emission sources. Leaf-air concentration factors (LACFs), calculated from linear regressions of the laboratory headspace data, were found to increase as the solvent extractable leaf lipid content and Koa value of the VOC increased. In the studies conducted in the residence, leaf concentrations paralleled the changing air concentrations, indicating a relatively rapid air to leaf VOC exchange. Overall, the data from the laboratory and residential studies illustrate the potential for plant leaves to be used as cost effective, real-time indoor air VOC samplers. (C) 2014 Elsevier Ltd. All rights reserved.

5. **L. Meciarova, S. Vilcekova and M. Balintova**, **Measurement of VOCs with a Portable GC/SAW Detector** (**2014**), Journal/Nose2014: 4th International Conference on Environmental Odour Monitoring and Control, Aidic Servizi Srl, 40, 283-288.

This paper describes the determination of the concentrations of volatile organic compounds (VOCs) in two Slovak buildings. Qualitative measurements were performed using an electronic nose, zNose (R) 4300. This device has been developed by Electronic Sensor Technology. Technology consists of a combination of gas chromatography with SAW (Surface Acoustic Wave) detector. This model was chosen for measurement because it provides a relatively fast results and full portability. Quantitative measurements were performed using a photoionization detector with UV lamp, ppbRAE 3000. Previous studies of indoor air in buildings showed that the occupant behaviour and consumer products influence indoor air quality, as well as building structures and location of the house. Our measurements were focused on VOCs, which are currently an important group of chemical pollutants. Term VOCs includes a wide range of hydrocarbons possessing a characteristic ability to vaporize at room temperature. VOCs are emitted from a large range of well-known sources. For example, from building materials, household products, human activities, cleaning, smoking, or industrial emissions, exhaust from vehicles are some of the anthropogenic sources of VOCs in the outdoor environment which contribute to indoor VOCs. Increased attention is also given to them because they can have a negative impact on human health. This study was carried out on the basis of complaints (smell, headache, nausea) of a laboratory worker, who has an office in the model house. Thus, the aim of this work was to determine what substances cause referred complaints and their possible sources.

6. **M. Brattoli, E. Cisternino, G. de Gennaro, P. Giungato, A. Mazzone, J. Palmisani and M. Tutino**, **Gas Chromatography Analysis with Olfactometric Detection (GC-O): an Innovative Approach for Chemical Characterizatio of Odor Active Volatile Organic Compounds (VOCs) Emitted from a Consumer Product** (**2014**), Journal/Nose2014: 4th International Conference on Environmental Odour Monitoring and Control, Aidic Servizi Srl, 40, 121-126.

The gas chromatography-olfactometry (GC-O) methodology couples traditional gas chromatographic analysis with sensory detection in order to identify odor active compounds in complex mixtures. Volatile Organic Compounds (VOCs) emitted from materials and consumer products can affect indoor air quality (IAQ) in terms of odor annoyance and other adverse effects on human health. Hence, the main purpose of the present paper was to recognize the odor active VOCs emitted by a specific consumer product and responsible of the odor annoyance perceived, performing head-space experiments followed by GC/MS-O analysis both at ambient temperature and during heating (condition of use). Ten odor active VOCs belonging to different chemical classes were detected; Aromatic Hydrocarbons (Benzene, Toluene, m/p-Xilene), Phenols (Phenol), Aldehydes (Benzaldehyde, Nonanale), Chlorinated Aromatic Hydrocarbons (Chlorobenzene, 1,4-Dichlorobenzene), Polycyclic Aromatic Hydrocarbons (Naphtalene) and Anhydrides (Phtalic Anhydride). Naphthalene was recognized as the organic compound that mainly contributed to the overall odor perceived. Moreover, it was observed that the product's heating resulted in an increasing of VOCs emission and in odor perception. Experimental data obtained highlighted the potentialities of GC/MS-O methodological approach to identify off-flavors deriving from materials and to provide useful indications to manufacturers to improve the acceptability of odorous emissions.

7. **O. V. Rodinkov, G. A. Zhuravlyova, E. A. Vaskova and I. A. Platonov**, **Potassium fluoride as a selective moisture trapping agent for SPE-TD-GC-FID determination of volatile organic compounds in air** (**2015**), Journal/Analytical Methods, 7, 458-465.

Anhydrous potassium fluoride has been proposed as a novel selective moisture trapping agent for gas chromatography to remove water vapor during adsorption concentration of low molecular weight volatile organic compounds (VOCs) from moist air. Unlike the traditional desiccants, potassium fluoride does not adsorb alcohols and ketones. To improve the adsorption efficiency, the analyzed air stream was purged through two sequential traps. The first trap was filled with a desiccant based on potassium fluoride and the second trap contained a sorbent to retain low molecular weight VOCs such as methanol and acetone. The adsorption of VOCs was followed by a thermal desorption from the second trap into the gas chromatographic column for analysis with a flame ionization detector. The proposed moisture trapping and preconcentration assembly allows determination of low molecular weight VOCs at the levels of mu g m(-3) with RSD not exceeding 5% after 4-8 minutes of preconcentration.

8. **C. Bur, M. E. Andersson, A. L. Spetz and A. Schutze**, **Detecting Volatile Organic Compounds in the ppb Range With Gas Sensitive Platinum Gate SiC-Field Effect Transistors** (**2014**), Journal/Ieee Sensors Journal, 14, 3221-3228.

In this paper, the use of a platinum gate gas-sensitive SiC field-effect transistor (SiC-FET) was studied for the detection of low concentrations of hazardous volatile organic compounds (VOCs). For this purpose, a new gas mixing system was realized providing VOCs down to sub-parts per billion levels with permeation ovens and gas predilution. Benzene, naphthalene, and formaldehyde were chosen as major indoor air pollutants and their characteristics are briefly reviewed. Measurements have shown that the selected VOCs can be detected by the SiC-FET in the parts per billion range and indicate a detection limit of similar to 1 ppb for benzene and naphthalene and similar to 10 ppb for formaldehyde in humid atmospheres. For 10-ppb naphthalene at 20% r.h., the sensor response is high with 12 mV, respectively, a relative response of 1.4%. Even in a background of 2-ppm ethanol, the relative response is still 0.3%. Quantification independent of the humidity level can be achieved using temperature cycled operation combined with pattern recognition, here linear discriminant analysis. Discrimination of benzene, naphthalene, and formaldehyde is also possible.

9. **F. Li, J. Jin, X. L. Sun, X. L. Wang, Y. Li, S. M. Shah and J. P. Chen**, **Gas chromatography-triple quadrupole mass spectrometry for the determination of atmospheric polychlorinated naphthalenes** (**2014**), Journal/Journal of Hazardous Materials, 280, 111-117.

Atmospheric polychlorinated naphthalenes (PCNs) ranging from mono-CNs to octa-CNs were detected using isotope-dilution gas chromatography coupled with triple quadrupole mass spectrometry (GC-MS/MS). The developed instrumental method was successfully applied to the determination of PCNs in technical products. It was observed that there were significant differences in concentrations, homologue profiles, chlorinated contents and total toxic equivalents (Sigma TEQs) of PCNs for four Halowax products. Subsequently, the validation of the analytical method was evaluated for the determination of PCNs in air samples in terms of method detection limit (MDL), recovery and matrix effect. The results demonstrated that this method could provide satisfactory sensitivity and adequate selectivity with lower cost. It was conducted to comprehensively evaluate the levels, composition patterns, Sigma TEQs, and daily intake exposure of PCNs in indoor and outdoor air samples.

Concentrations and Sigma TEQs of PCNs in air samples ranged 47.7-832.7 pg m(-3) and 1.31-5.99 fg m(-3), respectively, and the predominant homologues were di- and tri-CNs in the gas phase. The results indicated that this analytical method was useful for the accurate and specific evaluation of dioxin-like toxicity and human exposure levels of PCNs in the atmosphere. (C) 2014 Elsevier B.V. All rights reserved.

b. COSV

10. **Y. B. Wang, S. O. Sojinu, J. L. Sun, H. G. Ni, H. Zeng and M. Y. Zou**, **Are cockroaches reliable bioindicators of persistent organic pollutant contamination of indoor environments?** (**2015**), Journal/Ecological Indicators, 50, 44-49.

We measured the concentrations of selected persistent organic pollutants (POPs) such as parent and halogenated polycyclic aromatic hydrocarbons (PAHs and HPAHs) and polybrominated diphenyl ethers (PBDEs) in indoor dust (ID) and indoor cockroach samples collected from Shenzhen, South China. Biota-dust accumulation factors (BDAFs) were computed and utilized to quantify targeted pollutant bioaccumulation in ID and cockroaches. Generally, halogenated compounds have higher BDAFs when compared to non-halogenated compounds. There are significant differences ($p < 0.05$) between the BDAFs of non-halogenated POPs (PAHs) and halogenated POPs (HPAHs and PBDEs). Correlation analysis of target pollutants' levels in ID and cockroaches were also conducted. The correlation coefficients for PAHs are less than 0.2 ($p > 0.5$) suggesting no significant relationship exists for PAHs between ID and cockroaches. In contrast, significant correlations exist for halogenated POPs (HPAH and PBDE) between ID and cockroaches (correlation coefficients >0.94,$p < 0.0001$). Based on this, the potential of cockroaches to be used as reliable bioindicators of POPs contamination of indoor environments was preliminarily evaluated. Our results indicate that indoor cockroaches may be useful bioindicator of indoor pollution for HPAHs and PBDEs contaminations. (C) 2014 Elsevier Ltd. All rights reserved.

11. **L. T. Lin, A. L. Tsai, Y. M. Tseng and S. W. Tsai**, **Passive sampling of airborne furan indoors by solid-phase microextraction** (**2015**), Journal/International Journal of Environmental Analytical Chemistry, 95, 45-56.

Furan may be formed in food under heat treatment and is highly suspected to appear in indoor air. The possible exposure to indoor furan raises concerns because it has been found to cause carcinogenicity and cytotoxicity in animals. To determine airborne furan, solid-phase microextraction (SPME) technique was utilised as a diffusive sampler. The Carboxen/Polydimethylsiloxane (CAR/PDMS, 75 mu m) fibre was used, and the SPME fibre assembly was inserted into a polytetrafluoroethene tubing. Furan of known concentrations was generated in Tedlar gas bags for the evaluation of SPME diffusive samplers. After sampling, the sampler was inserted into the injection port of a gas chromatograph coupled with a mass spectrometer (GC/MS) for thermal desorption and analysis. Validation of the SPME device with active sampling by charcoal tube was performed side by side as well. The charcoal tube was desorbed by acetone before analysis with GC/MS. The experimental sampling constant of the sampler was found equal to (9.93 +/- 1.28)x10(-)(3) (cm(3)min(-1)) at 25 degrees C. Furthermore, side-by-side validations between SPME device and charcoal tube showed linear relationship with r=0.9927. The designed passive sampling device for furan has the advantages of both passive sampling and SPME technique and looks suitable for assessing indoor air quality.

12. **M. L. Fang and H. M. Stapleton**, **Evaluating the Bioaccessibility of Flame Retardants in House Dust Using an In Vitro Tenax Bead-Assisted Sorptive Physiologically Based Method** (**2014**), Journal/Environmental Science & Technology, 48, 13323-13330.

Exposure to house dust is a significant source of exposure to flame retardant chemicals (Fits), particularly in the US. Given the high exposure there is a need to understand the bioaccessibility of Fits from dust. In this study, Tenax beads (TA) encapsulated within a stainless steel insert were used as an adsorption sink to estimate the dynamic absorption of a suite of Fits commonly detected in indoor dust samples (n = 17), and from a few polyurethane foam samples for comparison. Organophosphate flame retardants (OPFRs) had the highest estimated bioaccessibility (similar to 80%) compared to brominated compounds (e.g., PBDEs), and values generally decreased with increasing Log K-OWT, with <30% bioaccessibility measured for BDE209. These measurements were in very close agreement with reported PBDE bioavailability measures from an in vivo rat exposure study using indoor dust. The bioaccessibility of very hydrophobic Fits (Log K-OW > 6) in foam was much less than that in house dust, and increasing bioaccessibility was observed with decreasing particle size. In addition, we examined the stability of more labile Fits containing ester groups (e g, OPFRs and 2-ethylhexyl-tetrabromo-benzoate (EH-TBB)) in a mock digestive fluid matrix. No significant changes in the OPFR concentrations were observed in this fluid; however, EH-TBB was found to readily hydrolyze to tetrabromobenzoic acid (TBBA) in the intestinal fluid in the presence of lipases. In conclusion, our study demonstrates that the bioaccessibility and stability of Fits following ingestion varies by chemical and sample matrix and thus should be considered in exposure assessments.

13. **C. Liaud, T. Dintzer, V. Tschamber, G. Trouve and S. Le Calve**, **Particle-bound PAHs quantification using a 3-stages cascade impactor in French indoor environments** (**2014**), Journal/Environmental Pollution, 195, 64-72.

Cascade Impactor is a powerful sampling method to collect airborne particles as a function of their size. The 3-stages Cascade Impactor used in this study allowed to sample simultaneously particles with aerodynamic diameter D-ae > 10 mu m, 2.5 mu m < D-ae < 10 mu m, 1 mu m < D-ae < 2.5 mu m and D-ae < 1 mu m. Once collected individual concentrations of the 16 US-EPA priority Polycyclic Aromatic Hydrocarbons (PAHs) bound to particles were quantified for 8 different indoor environments located in Strasbourg area in France. All the heavy PAHs owning between 4 and 6 aromatic rings were detected in all of the 8 sampling sites. The total PAHs concentration varied from 0.44 to 2.09 ng m(-3) for a low-energy building school and a smoking apartment, respectively. Results revealed also that high molecular weight PAHs were mainly associated to the finest particles. Our data are consistent with those measured elsewhere in European indoor environments. (C) 2014 Elsevier Ltd. All rights reserved.

14. **P. Bohlin, O. Audy, L. Skrdlikova, P. Kukucka, S. Vojta, P. Pribylova, R. Prokes, P. Cupr and J. Klanova**, **Evaluation and guidelines for using polyurethane foam (PUF) passive air samplers in double-dome chambers to assess semi-volatile organic compounds (SVOCs) in non-industrial indoor environments** (**2014**), Journal/Environmental Science-Processes & Impacts, 16, 2617-2626.

Indoor air pollution has been recognized as an important risk factor for human health, especially in areas where people tend to spend most of their time indoors. Many semi-volatile organic compounds (SVOCs) have primarily indoor sources and are present in orders of magnitude higher concentrations indoors than outdoors. Despite this,

awareness of SVOCs in indoor air and assessment of the link between indoor concentrations and human health have tagged behind those of outdoor air. This is partially related to challenges associated with indoor sampling of SVOCs. Passive air samplers (PASs), which are widely accepted in established outdoor air monitoring networks, have been used to fill the knowledge gaps on indoor SVOCs distribution. However, their applicability for indoor environments and the assessment of human health risks lack sufficient experimental data. To address this issue, we performed an indoor calibration study of polyurethane foam (PUF) PAS deployed in a double-dome chamber, covering both legacy and new SVOC classes. PUF-PAS and a continuous low-volume active air sampler (AAS) were co-deployed for a calibration period of twelve weeks. Based on the results from this evaluation, PUF-PAS in a double-bowl chamber is recommended for indoor sampling and health risk assessment of gas phase SVOCs, including novel brominated flame retardants (nBFR) providing sufficient exposure time is applied. Data for particle associated SVOCs suffered from significant uncertainties caused by low level of detection and low precision in this study. A more open chamber design for indoor studies may allow for higher sampling rates (R-s) and better performance for the particle associated SVOCs.

I.3   Réactions chimiques

15. **J. Zheng, P. Liu and F. Huang**, **Photocatalytic Degradation of Volatile Organic Compounds in an Annular Reactor Under Realistic Indoor Conditions** (**2015**),   Journal/Environmental Engineering Science, 32, 331-339.

This article presents an experimental investigation of the photocatalytic oxidation of several volatile organic compounds (formaldehyde, benzene, and toluene) under realistic indoor conditions. A novel annular reactor coated with TiO2 was designed to perform kinetic studies on (1) pollutant removal, (2) mineralization by CO2 formation, and (3) intermediate formation and removal in the gas phase. The pollutant(s) was/were injected at a constant rate in a 1.95-m(3) environmental chamber ventilated at a constant rate between 3.8 and 4.2 m(3)/h. The annular reactor was installed on an external recirculation loop, and processed air was reintroduced into the chamber. Recirculation rates were set at 25-200 m(3)/h, corresponding to recycle ratios between 6 and 50. Reaction area and residence time were greatly increased when fins were added in the annular reactor, and the removal efficiency and mineralization rate were, therefore, obviously improved. The pressure drop produced by the fins was insignificant and increased as a function of the recirculation rate. Intermediates were identified by using the GC-MS instrument, and GC-FID was used for the CO2 measurements. Benzaldehyde, benzyl alcohol, benzene, phenol, and acetone (or propionaldehyde) were the main intermediates in the gas phase. Increase in residence time for a reactor operating in a high face velocity regime was an important factor that led to the complete oxidation of primary and secondary pollutants. For mixture oxidation, selectivity toward benzene and toluene blocked the elimination of formaldehyde. A simple model was developed to predict removal efficiency by the recycle ratio. Model predictions showed good agreement with the experimental results.

16. **M. S. Waring and J. R. Wells**, **Volatile organic compound conversion by ozone, hydroxyl radicals, and nitrate radicals in residential indoor air: Magnitudes and impacts of oxidant sources** (**2015**), Journal/Atmospheric Environment, 106, 382-391.

Indoor chemistry may be initiated by reactions of ozone (O-3), the hydroxyl radical (OH), or the nitrate radical (NO3) with volatile organic compounds (VOC). The principal indoor source of O-3 is air exchange, while OH and NO3 formation are considered as primarily from O-3

reactions with alkenes and nitrogen dioxide (NO2), respectively. Herein, we used time-averaged models for residences to predict O-3, OH, and NO3 concentrations and their impacts on conversion of typical residential VOC profiles, within a Monte Carlo framework that varied inputs probabilistically. We accounted for established oxidant sources, as well as explored the importance of two newly realized indoor sources: (i). the photolysis of nitrous acid (HONO) indoors to generate OH and (ii) the reaction of stabilized Criegee intermediates (SCI) with NO2 to generate NO3. We found total VOC conversion to be dominated by reactions both with O-3, which almost solely reacted with D-limonene, and also with OH, which reacted with D-limonene, other terpenes, alcohols, aldehydes, and aromatics. VOC oxidation rates increased with air exchange, outdoor O-3, NO2 and D-limonene sources, and indoor photolysis rates; and they decreased with O-3 deposition and nitric oxide (NO) sources. Photolysis was a strong OH formation mechanism for high NO, NO2, and HONO settings, but SCI/NO2 reactions weakly generated NO3 except for only a few cases. (C) 2014 Elsevier Ltd. All rights reserved.

17. **M. Vesely, Z. Vajglova, P. Kotas, J. Kristal, R. Ponec and V. Jiricny**, **Model for photodegradation of polybrominated diphenyl ethers** (**2015**), Journal/Environmental Science and Pollution Research, 22, 4949-4963.

Polybrominated diphenyl ethers (PBDE) were, and in some countries still are, used as flame retardants for plastic materials. When released from plastics, PDBE cause harm to the environment. This creates the incentive for further investigation of the PBDE degradation. This work focused on a formulation of a PBDE photodegradation model based on the PBDE properties obtained by the quantum chemical calculations. The proposed model predicted degradation routes of arbitrary PBDE congener. The routes of selected congeners were validated by the two independently published data sets and showed the high fitting degree. The model can be easily modified for any reactor system if the initial reaction rate constant of one congener is available for the given system.

18. **H. H. Wang, Y. M. Ji, Y. P. Gao, G. Y. Li and T. C. An**, **Theoretical model on the formation possibility of secondary organic aerosol from (OH)-O-center dot initialed oxidation reaction of styrene in the presence of O-2/NO** (**2015**), Journal/Atmospheric Environment, 101, 1-9.

Understanding (OH)-O-center dot oxidation reaction is vital in understanding atmospheric pollution dynamics, and developing possible strategies for countering pollutant problems. This study used a theory-based approach to model the formation mechanisms of secondary organic aerosol (SOA) from styrene-(OH)-O-center dot oxidation reactions in the presence of O-2/NO. As a comparative measure, the mechanisms in the absence of NO (representing a pollution-free environment) were also investigated. The results showed that styrene can be initially attacked by (OH)-O-center dot in two ways: OH-addition and H-abstraction. The OH-aliphatic-addition pathway occurs easily; the H-abstraction pathway may be ignored given atmospheric conditions. It was found that IMaddi beta (C6H5CHCH2OH) was the main intermediate, and could be transformed to a peroxyl radical in the presence of O-2. In the NO-free atmosphere, the peroxyl radical was decomposed to recycling-(OH)-O-center dot and aldehydes. In the NO-polluted atmosphere, it could be degraded to organic nitrate (RO-NO2) which plays an important role in the production of SOA. Besides, the percent of organic nitrate in the particulate phase was calculated within the range of 2.4%-63% in Guangzhou city, and organic nitrates may constitute an important fraction of the total organic aerosol. The kinetic data calculated using canonical variational transition state theory with the small-curvature tunneling correction showed that, in the NO-polluted/unpolluted atmospheres, the styrene-(OH)-O-center dot oxidation reaction easily occurred across an altitude range of 0-12 km. Especially, peroxyl radical lifetime was 10(-3) s in the high NO-polluted atmosphere,

indicating that the styrene-(OH)-O-center dot oxidation reaction could significantly contribute to SOA formation in the NO-polluted atmosphere. The current results informed possible approaches for forming SOA from volatile organic compound (VOC) oxidation reactions, and could help evaluate regional air quality, especially in high NO-polluted atmospheres. (C) 2014 Elsevier Ltd. All rights reserved.

I.4   Émission des matériaux

19. **E. Uhde and N. Schulz**, **Impact of room fragrance products on indoor air quality** (**2015**), Journal/Atmospheric Environment, 106, 492-502.

Everyday life can no longer be imagined without fragrances and scented products. For the consumer, countless products exists which are solely or partly intended to give off a certain scent in sufficient concentrations to odorize a complete room. Sprays, diffusers and evaporators, scented candles and automatic devices for the distribution of fragrance liquids are typical examples of such products. If the consumer uses such products, his consent to the release of certain chemicals in his home can be implied, however, he may not know what kind of fragrance substances' and solvents will be present in which concentrations. In this study, we determined the volatile emissions of a number of fragrance products in detail. Measurements were carried out under controlled conditions in test chambers. The products were tested in a passive (unused) and an active state, wherever applicable. Following a defined test protocol, the release of volatile organic compounds, ultrafine particles and NOx was monitored for each product. The potential for forming secondary organic aerosols under the influence of ozone was studied, and for a selection of products the long-term emission behavior was assessed. A remarkable variety of fragrance substances was found and more than 100 relevant compounds were identified and quantified. While it is the intended function of such products to release fragrance substances, also considerable amounts of non-odorous solvents and by-products were found to be released from several air fresheners. Emissions rates exceeding 2 mg/(unit*h) were measured for the five most common solvents. (C) 2014 Elsevier Ltd. All rights reserved.

20. **J. H. Ahn, K. H. Kim, Y. H. Kim and B. W. Kim**, **Characterization of hazardous and odorous volatiles emitted from scented candles before lighting and when lit** (**2015**), Journal/Journal of Hazardous Materials, 286, 242-251.

Scented candles are known to release various volatile organic compounds (VOCs) including both pleasant aromas and toxic components both before lighting (off) and when lit (on). In this study, we explored the compositional changes of volatiles from scented candles under various settings to simulate indoor use. Carbonyl compounds and other VOCs emitted from six different candle types were analyzed under 'on/off' conditions. The six candle types investigated were: (1) Clean cotton (CT), (2) Floral (FL), (3) Kiwi melon (KW), (4) Strawberry (SB), (5) Vanilla (VN), and (6) Plain (PL). Although a large number of chemicals were released both before lighting and when lit, their profiles were noticeably distinguishable. Before lighting, various esters (n=30) showed the most dominant emissions. When lit, formaldehyde was found to have the highest emission concentration of 2098 ppb (SB), 1022 ppb (Cr), and 925 ppb (PL). In most lit scented candles, there was a general tendency to show increased concentrations of low boiling point compounds. For some scented candle products, the emission of volatiles occurred strongly both before lighting and when lit. For instance, in terms of TVOC (ppbC), the highest concentrations were observed from the KW product with their values of 12,742 (on) and 2766 ppbC (off). As such, the results suggest that certain scented candle products should act as potent sources of VOC emission in indoor

environment, regardless of conditions - whether being lit or not. (C) 2014 Elsevier B.V. All rights reserved.

21. **A. Schieweck and M. C. Bock**, **Emissions from low-VOC and zero-VOC paints - Valuable alternatives to conventional formulations also for use in sensitive environments?** (**2015**), Journal/Building and Environment, 85, 243-252.

The reduction of solvents in paint formulations constitutes a major effort in order to provide environmentally-friendly products that are not harmful to human health. A promising alternative to conventional formulations may be those with very low content or no presence of volatile organic compounds (VOCs), so-called "low-VOC" and "zero-VOC" interior paints. Sample specimen were mainly produced in the U.S. and labelled as "green" products by a variety of different certification marks. The content of semi-volatile organic compounds (SVOCs) and the emission potential was studied by means of solvent extraction and chamber emission tests. It was found that all paints contain SVOCs in order to circumvent solvent classifications. Even though the spectrum of emitted substances was limited under test chamber conditions, the emission potential was very high due to the increased release of individual VOCs/SVOCs. Additionally, the paints released heightened acetic acid levels and are therefore not favored for the use in sensitive environments. The manufacturers' recommendations that the paints emit low or negligible levels of VOCs/SVOCs with no need for long periods of ventilation after application could not be confirmed by this study. The same applies to so-called air purifying paints that should adsorb airborne pollutants. Thus, sufficient ventilation time before re-occupying renovated rooms is required, especially in the presence of sensitive persons, young children and elderly people. It is strongly recommended to check product certifications thoroughly and to make a decision on the basis of material emission tests in order to assess if a product fulfills the personal requirements. (C) 2014 Elsevier Ltd. All rights reserved.

22. **Y. R. Liang and Y. Xu**, **The influence of surface sorption and air flow rate on phthalate emissions from vinyl flooring: Measurement and modeling** (**2015**), Journal/Atmospheric Environment, 103, 147-155.

This study investigated the influences of surface sorption and air flow rate on the emission of phthalates from building materials. Controlled tests were conducted in specially designed stainless steel and wood chambers, and the steady-state concentration in the stainless steel chamber was about 2-3 times higher than that in the wood chamber for di(2-ethylhexyl) phthalate (DEHP) and diisononyl phthalate (DINP). The emission rate of phthalates increased in the wood chamber due to the diffusion mass flow through the chamber wall (i.e., surface absorption). The adsorption isotherm of phthalates on the stainless steel surface and the absorption parameters (i.e., diffusion and partition coefficients) of phthalates on the wood surface were determined experimentally, and the values were comparable to those in the literature. The equilibration time scale for phthalates absorbed to the sink reservoir in actual indoor environments was estimated and can be substantial (approximately 80 years), indicating that surface absorption may continuously drive phthalates from their indoor sources to various sinks and thus significantly increase the emission rate of phthalates. The gas-phase concentration of DEHP was measured in two stainless steel chambers operated at flow rates of 300 mL/min and 3000 mL/min, respectively, which were both adjusted to 1000 mL/min after steady state was reached. The gas-phase concentration of DEHP in the chamber was very sensitive to the chamber air flow rate, and higher air flow rates resulted in lower concentration levels. However, the increased emission rate compensated for the dilution in the gas phase and made the DEHP concentration not drop substantially with an increase in the air flow rate. Independently measured or calculated parameters were used to validate a semivolatile organic compounds (SVOCs) emission model that included absorptive

surfaces and for a range of air flow rates, with excellent agreement between the model predictions and the observed chamber concentrations of phthalates. (C) 2014 Elsevier Ltd. All rights reserved.

23. **M. Lazaridis, N. Serfozo, S. E. Chatoutsidou and T. Glytsos**, **New particle formation events arising from painting materials in an indoor microenvironment** (**2015**), Journal/Atmospheric Environment, 102, 86-95.

Particulate matter (PM) number size distribution and mass concentration along with total volatile organic compounds (TVOC) were measured during emissions from painting materials inside an indoor microenvironment. The emission sources were derived from oil painting medium and turpentine used for painting. Two sets of measurements (10 experiments) were conducted in a laboratory room of 54 m(3). New particle formation events were observed in all 10 experiments. The nucleation events lasted on average less than one hour with an average growth rate 33.9 +/- 9.1 nm/h and average formation rate 21.1 +/- 8.7 cm(-3)s(-1). After the end of the nucleation event, a condensational growth of indoor particles followed with average growth rate 11.6 +/- 2.8 nm/h and duration between 1.4 and 4.1 h. High concentrations up to 3.24 ppm were measured for the indoor TVOC concentrations during the experiments. Simultaneous mass and number size concentration measurements were performed outdoors where no new particle formation event was observed. It is the first time that high nucleation rates indoors were observed in conjunction with high TVOC concentrations originating from painting materials which resulted to high exposure concentration levels of particle number concentration. (C) 2014 Elsevier Ltd. All rights reserved.

24. **R. Nagorka, C. Gleue, C. Scheller, H. J. Moriske and W. Straff**, **Isothiazolone emissions from building products** (**2015**), Journal/Indoor Air, 25, 68-78.

Adding biocides to dispersion products is a well-known practice to control microbial deterioration. Isothiazolones are among the most commonly used preservatives, in particular a mixture of 2-methyl-2H-isothiazol-3-one (MIT) and 5-chloro-2-methyl-2H-isothiazol-3-one (CIT). In recent years, for health reasons, due to its strong sensitizing effect, CIT has been replaced by 1,2-benzisothiazol-3-one (BIT). Furthermore, numerous products are now available for interiors containing the fungicidal active substance 2-octyl-2H-isothiazol-3-one (OIT). So far nearly nothing is known of the emission behavior of BIT and OIT. An analytical method was developed for these two isothiazolones and interior products containing BIT respectively OIT have been investigated in an emission chamber and in test rooms. The chamber tests revealed maximum concentrations of 6.7g OIT/m(3), 1.9g BIT/m(3), and 187g MIT/m(3). Concentrations obtained in the test rooms were at levels up to 1.4g OIT/m(3) and 29g MIT/m(3). A noticeable finding was the very slight subsidence of OIT and BIT levels over several weeks. While MIT outgassed quickly, OIT in particular showed low concentrations, but prolonged evaporation.

25. **Y. R. Liang and Y. Xu**, **Emission of Phthalates and Phthalate Alternatives from Vinyl Flooring and Crib Mattress Covers: The Influence of Temperature** (**2014**), Journal/Environmental Science & Technology, 48, 14228-14237.

Emissions of phthalates and phthalate alternatives from vinyl flooring and crib mattress covers were measured in a specially designed chamber. The gas-phase concentrations versus time were measured at four different temperatures, that is, 25, 36, 45, and 55 degrees C. The key parameter that controls the emissions (y(0), gas-phase concentration in

equilibrium with the material phase) was determined, and the emissions were found to increase significantly with increasing temperature. Both the material-phase concentration (C-0) and the chemical vapor pressure (V-p) were found to have great influence on the value of y(0). The measured ratios of C-0 to y(0) were exponentially proportional to the reciprocal of temperature, in agreement with the vant Hoff equation. A emission model was validated at different temperatures, with excellent agreement between model calculations and chamber observations. In residential homes, an increase in the temperature from 25 to 35 degrees C can elevate the gas-phase concentration of phthalates by more than a factor of 10, but the total airborne concentration may not increase that much for less volatile compounds. In infant sleep microenvironments, an increase in the temperature of mattress can cause a significant increase in emission of phthalates from the mattress cover and make the concentration in the infants breathing zone about four times higher than that in the bulk room air, resulting in potentially high exposure.

26. **A. Stachowiak-Wencek, M. Zborowska, W. Pradzynski and B. Waliszewska**, **Emissions of volatile organic compounds from lacquer coatings used in the furniture industry, modified with nanoparticles of inorganic metal compounds** (**2015**), Journal/Turkish Journal of Agriculture and Forestry, 39, 251-259.

This study presents results of studies on emissions of volatile organic compounds from lacquer products containing nanoparticles of inorganic metal compounds (SiO_2, TiO_2, and Ag). The lacquers selected for analyses were applied on the surface of Scots pine (Pinus sylvestris L.) wood. Tests were conducted by gas chromatography coupled with mass spectrometry and thermal desorption. Concentrations of volatile organic compounds (VOCs) released to the air by tested coatings in the first stage of the analyses fell within a very broad range (307-1829 mu g/m(3)). Analyses of VOC emissions were conducted after 1, 3, 5, 7, 10, 30, 60, and 90 days. After 90 days VOC concentrations were significantly lower, ranging from 42 to 101 mu g/m(3). A broad spectrum of compounds, comprising aldehydes, esters, ketones, aliphatic and aromatic hydrocarbons, alcohols, glycols, and terpenes, was identified in the tested air.

27. **W. Ye, S. S. Cox, X. M. Zhao, C. E. Frazier and J. C. Little**, **Partially-irreversible sorption of formaldehyde in five polymers** (**2014**), Journal/Atmospheric Environment, 99, 288-297.

Due to its environmental ubiquity and concern over its potential toxicity, the mass-transfer characteristics of formaldehyde are of critical importance to indoor air quality research. Previous studies have suggested that formaldehyde mass transfer in polymer is partially irreversible. In this study, mechanisms that could cause the observed irreversibility were investigated. Polycarbonate and four other polymeric matrices were selected and subjected to formaldehyde sorption/desorption cycles. Mass transfer of formaldehyde was partially irreversible in all cases, and three potential mechanisms were evaluated. First, attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR) analysis was used to investigate possible formaldehyde polymerization on polymer surfaces. ATR-FTIR showed no detectable paraformaldehyde or formaldehyde on the film surfaces that had been exposed to formaldehyde and air. ATR-FTIR did detect aliphatic acids suggesting oxidation had occurred on film surfaces as a result of exposure to formaldehyde. However, additional study suggested that air is not the primary cause for irreversibility. Second, statistical physics theory was tested as a possible explanation. According to this theory, reversible and irreversible sorption could be taking place simultaneously. The irreversible fraction should be constant during sorption and the fraction could be determined by performing a complete sorption/desorption test. The sorption/desorption data was consistent with this theory. Third, chemisorption was considered as another possible cause for irreversibility. Extraction/fluorimetry testing of post-sorption and post-desorption polymer films showed

measurable quantities of formaldehyde suggesting that some of the chemisorbed formaldehyde was reversible at the higher extraction temperature. Further quantitative study on chemical reaction products is needed. (C) 2014 Elsevier Ltd. All rights reserved.

28. **D. Bourdin, P. Mocho, V. Desauziers and H. Plaisance**, **Formaldehyde emission behavior of building materials: On-site measurements and modeling approach to predict indoor air pollution** (**2014**), Journal/Journal of Hazardous Materials, 280, 164-173.

The purpose of this paper was to investigate formaldehyde emission behavior of building materials from on-site measurements of air phase concentration at material surface used as input data of a box model to estimate the indoor air pollution of a newly built classroom. The relevance of this approach was explored using CFD modeling. In this box model, the contribution of building materials to indoor air pollution was estimated with two parameters: the convective mass transfer coefficient in the material/air boundary layer and the on-site measurements of gas phase concentration at material surfaces. An experimental method based on an emission test chamber was developed to quantify this convective mass transfer coefficient. The on-site measurement of gas phase concentration at material surface was measured by coupling a home-made sampler to SPME. First results had shown an accurate estimation of indoor formaldehyde concentration in this classroom by using a simple box model. (C) 2014 Elsevier B.V. All rights reserved.

I.5 Particules et fibres

Rubrique N°3

29. **J. Niu, P. E. Rasmussen, R. Magee and G. Nilsson**, **Spatial and temporal variability of incidental nanoparticles in indoor workplaces: impact on the characterization of point source exposures** (**2015**), Journal/Environmental Science-Processes & Impacts, 17, 98-109.

This study deployed a suite of direct-reading instruments in six locations inside one building to characterize variability of the background aerosol, including incidental nanoparticles (NP), over a six month period. The instrument suite consisted of a portable Condensation Particle Counter (CPC) and a Scanning Mobility Particle Sizer (SMPS) for assessing particle number concentrations and size distributions in the nano-scale range; an Aerodynamic Particle Sizer (APS) for assessing micron-scale particle number concentrations and size distributions; plus a desktop Aerosol Monitor (DustTrak DRX) and a Diffusion Charger (DC2000CE) for assessing total particle mass and surface area concentrations respectively. In terms of number concentration, NPs (<100 nm) were the dominant particles observed in the background aerosol, contributing up to 53-93% of the total particle number concentrations. The particle size distributions were bimodal with maxima around 19-79 nm and 50-136 nm, respectively, depending on workplace locations. The average detected background particle number, surface area and total mass concentrations were below 7.1 x 10(3) # cm(-3), 22.9 mu m(2) cm(-3) and 33.5 mu g m(-3), respectively in spring samples and below 1.8 x 10(3) # cm-3, 10.1 mu m(2) cm(-3) and 12.0 mg m(-3), respectively in winter samples. A point source study using an older model laser printer as the emission source indicated that NPs emitted from the investigated printer were distinguishable from background. However, more recent low emitting printers are likely to be indistinguishable from background, and chemical characterization (e.g. VOCs, metals) would be required to help identify emission sources.

I.6 Biocontaminants

Rubrique N°4

30. **S. Bhangar, J. A. Huffman and W. W. Nazaroff**, **Size-resolved fluorescent biological aerosol particle concentrations and occupant emissions in a university classroom** (**2014**), Journal/Indoor air, 24, 604-617.

This study is among the first to apply laser-induced fluorescence to characterize bioaerosols at high time and size resolution in an occupied, common-use indoor environment. Using an ultraviolet aerodynamic particle sizer, we characterized total and fluorescent biological aerosol particle (FBAP) levels (1-15mum diameter) in a classroom, sampling with 5-min resolution continuously during eighteen occupied and eight unoccupied days distributed throughout a one-year period. A material-balance model was applied to quantify per-person FBAP emission rates as a function of particle size. Day-to-day and seasonal changes in FBAP number concentration (NF) values in the classroom were small compared to the variability within a day that was attributable to variable levels of occupancy, occupant activities, and the operational state of the ventilation system. Occupancy conditions characteristic of lecture classes were associated with mean NF source strengths of 2*10(6) particles/h/person, and 9*10(4) particles per metabolic g CO_2 . During transitions between lectures, occupant activity was more vigorous, and estimated mean, per-person NF emissions were 0.8*10(6) particles per transition. The observed classroom peak in FBAP size at 3-4mum is similar to the peak in fluorescent and biological aerosols reported from several studies outdoors. 2014 The Authors. Indoor Air Published by John Wiley & Sons Ltd.

I.7 Ventilation

Rubrique N° 5

31. **A. Fischer, E. Ljungstrom, L. Hagerhed Engman and S. Langer**, **Ventilation strategies and indoor particulate matter in a classroom** (**2015**), Journal/Indoor Air, 25, 168-175.

Particle mass and number concentrations were measured in a mechanically ventilated classroom as part of a study of ventilation strategies for energy conservation. The ventilation system was operated either continuously, intermittently, or shut down during nights while it was on during workdays. It appears that the nighttime ventilation scheme is not important for indoor particle concentrations the following day if fans are operated to give five air exchanges in advance of the workday. The highest concentrations of PM10 were found during and after workdays and were due to human activity in the classroom. The average workday PM10 concentration was 14g/m(3), well below the WHO guideline values. The number concentration of particles with diameter <0.750m was typically between 0.5x10(3) and 3.5x10(3)particle/cm(3). These concentrations were largely independent of the occupants. Transient formation of small particles was observed when ventilation was shut down. Then remaining ozone reacted with terpenes emitted by indoor sources and gave up to 8x10(3)particle/cm(3) before formation stopped due to lack of ozone. The intermittent ventilation regime was found least favorable for the indoor air quality in the classroom.

I.8 Modélisation

Rubrique N° 6

32. **A. C. Rai, C. H. Lin and Q. Y. Chen**, **Numerical modeling of particle generation from ozone reactions with human-worn clothing in indoor environments** (**2015**), Journal/Atmospheric Environment, 102, 145-155.

Ozone-terpene reactions are important sources of indoor ultrafine particles (UFPs), a potential health hazard for human beings. Humans themselves act as possible sites for ozone-initiated particle generation through reactions with squalene (a terpene) that is present in their skin, hair, and clothing. This investigation developed a numerical model to probe particle generation from ozone reactions with clothing worn by humans. The model was based on particle generation measured in an environmental chamber as well as physical formulations of particle nucleation, condensational growth, and deposition. In five out of the six test cases, the model was able to predict particle size distributions reasonably well. The failure in the remaining case demonstrated the fundamental limitations of nucleation models. The model that was developed was used to predict particle generation under various building and airliner cabin conditions. These predictions indicate that ozone reactions with human-worn clothing could be an important source of UFPs in densely occupied classrooms and airliner cabins. Those reactions could account for about 40% of the total UFPs measured on a Boeing 737-700 flight. The model predictions at this stage are indicative and should be improved further. (C) 2014 Elsevier Ltd. All rights reserved.

I.9 Études/ méthode

Rubrique N° 7

33. **M. Maciejewska and A. Szczurek**, **Representativeness of shorter measurement sessions in long-term indoor air monitoring** (**2015**), Journal/Environmental Science-Processes & Impacts, 17, 381-388.

Indoor air quality (IAQ) considerably influences health, comfort and the overall performance of people who spend most of their lives in confined spaces. For this reason, there is a strong need to develop methods for IAQ assessment. The fundamental issue in the quantitative determination of IAQ is the duration of measurements. Its inadequate choice may result in providing incorrect information and this potentially leads to wrong conclusions. The most complete information may be acquired through long-term monitoring. However it is typically perceived as impractical due to time and cost load. The aim of this study was to determine whether long-term monitoring can be adequately represented by a shorter measurement session. There were considered three measurable quantities: temperature, relative humidity and carbon dioxide concentration. They are commonly recognized as indicatives for IAQ and may be readily monitored. Scaled Kullback-Leibler divergence, also called relative entropy, was applied as a measure of data representativeness. We considered long-term monitoring in a range from 1 to 9 months. Based on our work, the representative data on CO_2 concentration may be acquired while performing measurements during 20% of time dedicated to long-term monitoring. In the case of temperature and relative humidity the respective time demand was 50% of long-term monitoring. From our results, in indoor air monitoring strategies, there could be considered shorter measurement sessions, while still collecting data which are representative for long-term monitoring.

34. **G. Suzuki, N. M. Tue, S. Takahashi, S. Tanabe, S. Sakai and H. Takigami**, **Effect-based Hazard Identification of House Dust by In Vitro Assays Detecting Dioxin-like Compounds, Thyroid and Reproductive Toxicants** (**2014**), Journal/Current Organic Chemistry, 18, 2231-2239.

Indoor dust is a sink for many kinds of pollutants, including flame retardants (FRs), plasticizers and various degradation products, derived from household products. Recently, we have put particular emphasis on the evaluation of indoor dust as an excellent indicator of important contaminants for chemical risk management throughout the lifecycle of household product. Our research has focused on effect-based approach using in vitro bioassays together with instrumental analyses in an attempt to conduct hazard characterization determining the presence and activity profile of contaminants detected in house dust. This approach will lead to a determination of priority pollutants, their impurities and by-products for further assessment from the list of chemicals manufactured and distributed worldwide. Here, we introduce some background studies and results obtained by using effect-based approach for house dust, revealing importance of dioxin-like compounds, thyroid and reproductive toxicants used and contained in household products. Based on outcomes from previous studies here summarized, it can be suggested that effect-based approach is a useful scheme to determine contaminants and endpoints in indoor dust for priority assessment on in vitro toxicological point of view. Further integration of exposure and effect analysis for indoor dust will lead to appropriate chemical risk management throughout various household products' lifecycles.

II. CONNAISSANCES DES CONCENTRATIONS ET DES EXPOSITIONS

II.1 Logement

Rubrique N°8

a.   COV

REVIEW

35. **M. Nadal and J. L. Domingo**, **Indoor Dust Levels of Perfluoroalkyl Substances (PFASs) and the Role of Ingestion as an Exposure Pathway: A Review** (**2014**), Journal/Current Organic Chemistry, 18, 2200-2208.

Perfluoroalkyl substances (PFASs) are emerging pollutants whose scientific knowledge has notably increased in the last two decades. Detectable amounts of PFASs, and particularly perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), have been found in the environment, wildlife and humans. Nowadays, the presence of PFASs and its global distribution is well known. However, there is still a high degree of uncertainty in the pathways of exposure through which PFASs enter the human body. Similarly to "classical" persistent organic pollutants (POPs), dietary intake seems to be the predominant exposure route, with water consumption being identified as a potentially important pathway. Since most human exposure to PFASs occurs in indoor environments, the inhalation of indoor air and the ingestion of dust might notably contribute to the total intake of PFASs. In fact, some investigations point out the possibility that, because of higher dust ingestion rates, the PFAS exposure for toddlers could be much higher than that for adults. Even more, the children intake of PFASs could be dominated by dust ingestion, instead of food as the most important exposure pathway. In this paper, we review a number of recent of studies reporting concentrations of PFASs in dust and estimations on the human exposure via dust ingestion. An important geographical variation among countries was observed, therefore indicating that the assessment of this pathway should be performed in a case-by-case basis.

36. **M. S. Waring and J. R. Wells**, **Volatile organic compound conversion by ozone, hydroxyl radicals, and nitrate radicals in residential indoor air: Magnitudes and impacts of oxidant sources** (**2015**), Journal/Atmospheric Environment, 106, 382-391.

Indoor chemistry may be initiated by reactions of ozone (O-3), the hydroxyl radical (OH), or the nitrate radical (NO3) with volatile organic compounds (VOC). The principal indoor source of O-3 is air exchange, while OH and NO3 formation are considered as primarily from O-3 reactions with alkenes and nitrogen dioxide (NO2), respectively. Herein, we used time-averaged models for residences to predict O-3, OH, and NO3 concentrations and their impacts on conversion of typical residential VOC profiles, within a Monte Carlo framework that varied inputs probabilistically. We accounted for established oxidant sources, as well as explored the importance of two newly realized indoor sources: (i). the photolysis of nitrous acid (HONO) indoors to generate OH and (ii) the reaction of stabilized Criegee intermediates (SCI) with NO2 to generate NO3. We found total VOC conversion to be dominated by reactions both with O-3, which almost solely reacted with D-limonene, and also with OH, which reacted with D-limonene, other terpenes, alcohols, aldehydes, and aromatics. VOC oxidation rates increased with air exchange, outdoor O-3, NO2 and D-limonene sources, and indoor photolysis rates; and they decreased with O-3 deposition and nitric oxide (NO) sources. Photolysis was a strong OH formation mechanism for high NO, NO2, and HONO

settings, but SCI/NO2 reactions weakly generated NO3 except for only a few cases. (C) 2014 Elsevier Ltd. All rights reserved.

37. **Y. Y. Xiong, U. Krogmann, G. Mainelis, L. A. Rodenburg and C. J. Andrews**, **Indoor air quality in green buildings: A case-study in a residential high-rise building in the northeastern United States** (**2015**), Journal/Journal of Environmental Science and Health Part a-Toxic/Hazardous Substances & Environmental Engineering, 50, 225-242.

Improved indoor air quality (IAQ) is one of the critical components of green building design. Green building tax credit (e.g., New York State Green Building Tax Credit (GBTC)) and certification programs (e.g., Leadership in Energy & Environmental Design (LEED)) require indoor air quality measures and compliance with allowable maximum concentrations of common indoor air pollutants. It is not yet entirely clear whether compliance with these programs results in improved IAQ and ultimately human health. As a case in point, annual indoor air quality measurements were conducted in a residential green high-rise building for five consecutive years by an industrial hygiene contractor to comply with the building's GBTC requirements. The implementation of green design measures resulted in better IAQ compared to data in references of conventional homes for some parameters, but could not be confirmed for others. Relative humidity and carbon dioxide were satisfactory according to existing standards. Formaldehyde levels during four out of five years were below the most recent proposed exposure limits found in the literature. To some degree, particulate matter (PM) levels were lower than that in studies from conventional residential buildings. Concentrations of Volatile Organic Compounds (VOCs) with known permissible exposure limits were below levels known to cause chronic health effects, but their concentrations were inconclusive regarding cancer health effects due to relatively high detection limits. Although measured indoor air parameters met all IAQ maximum allowable concentrations in GBTC and applicable LEED requirements at the time of sampling, we argue that these measurements were not sufficient to assess IAQ comprehensively because more sensitive sampling/analytical methods for PM and VOCs are needed; in addition, there is a need for a formal process to ensure rigor and adequacy of sampling and analysis methods. Also, we suggest that a comprehensive IAQ assessment should include mixed mode thermal comfort models, semi-volatile organic compounds, assessment of new chemicals, and permissible exposure levels of many known indoor VOCs and bioaerosols. Plus, the relationship between energy consumption and IAQ, and tenant education on health effects of indoor pollutants and their sources may need more attention in IAQ investigations in green buildings.

38. **P. Markowicz and L. Larsson**, **Influence of relative humidity on VOC concentrations in indoor air** (**2015**), Journal/Environmental Science and Pollution Research, 22, 5772-5779.

Volatile organic compounds (VOCs) may be emitted from surfaces indoors leading to compromised air quality. This study scrutinized the influence of relative humidity (RH) on VOC concentrations in a building that had been subjected to water damage. While air samplings in a damp room at low RH (21-22 %) only revealed minor amounts of 2-ethylhexanol (3 mu g/m(3)) and 2,2,4-trimethyl-1,3-pentanediol diisobutyrate (TXIB, 8 mu g/m(3)), measurements performed after a rapid increase of RH (to 58-75 %) revealed an increase in VOC concentrations which was 3-fold for 2-ethylhexanol and 2-fold for TXIB. Similar VOC emission patterns were found in laboratory analyses of moisture-affected and laboratory-contaminated building materials. This study demonstrates the importance of monitoring RH when sampling indoor air for VOCs in order to avoid misleading conclusions from the analytical results.

b.   COSV

REVIEW
39. **W. L. Ma, B. Subedi and K. Kannan**, **The Occurrence of Bisphenol A, Phthalates, Parabens and Other Environmental Phenolic Compounds in House Dust: A Review** (**2014**), Journal/Current Organic Chemistry, 18, 2182-2199.

Dust from indoor environments can contain significant amounts environmental contaminants and is an important source of human exposure to several toxicants. In this article, studies on the occurrence of several emerging environmental contaminants, namely bisphenol A (BPA), tetrabromobisphenol A (TBBPA), phthalates, parabens, and other environmental phenolic compounds in indoor dust from various countries, were reviewed. Issues associated with sampling of dust and the uncertainties introduced in the analytical procedures were also summarized. Finally, exposure to environmental phenolic compounds through dust ingestion was evaluated, and the contribution of indoor dust to the total daily exposure of toxicants was estimated. Overall, the reported concentrations of target chemicals in dust were found, in decreasing order, as phthalates (overall mean: 949 +/- 669 mu g/g, range: 0.9-10,900 mu g/g) >>> nonylphenol (8.9 +/- 6.8 mu g/g, 2.6-29.2 mu g/g) > BPA (3.6 +/- 4.5 mu g/g, 0.35-16.6 mu g/g) > parabens (1.53 +/- 0.52 mu g/g, 0.03-125 mu g/g) > pentachlorophenol (1.39 +/- 2.31 mu g/g, 0.050-5.76 mu g/g) > triclosan (0.65 +/- 0.23 mu g/g, 0.38-0.93 mu g/g) > TBBPA (0.18 +/- 0.14 mu g/g, 0.049-0.505 mu g/g). Despite the elevated levels of the target phenolic compounds reported in indoor dust, exposure of humans through dust ingestion was minor. Nevertheless, dust can be a significant source of exposure to phenolic compounds for infants and toddlers. Elevated levels of phenolic compounds were found in dust collected from certain microenvironments such as offices and laboratories.

40. **T. M. Tran and K. Kannan**, **Occurrence of Phthalate Diesters in Particulate and Vapor Phases in Indoor Air and Implications for Human Exposure in Albany, New York, USA** (**2015**), Journal/Archives of Environmental Contamination and Toxicology, 68, 489-499.

Phthalate diesters are used as plasticizers in a wide range of consumer products. Because phthalates have been shown in laboratory animal studies to be toxic, human exposure to these chemicals is a matter of concern. Nevertheless, little is known about inhalation exposure to phthalates in the United States. In this study, occurrence of nine phthalates was determined in 60 indoor air samples collected in 2014 in Albany, New York, USA. Airborne particulate and vapor phase samples were collected from various sampling locations by use of a low-volume air sampler. The median concentrations of nine phthalates in air samples collected from homes, offices, laboratories, schools, salons (hair and nail salons), and public places were 732, 143, 170, 371, 2600, and 354 ng/m(3), respectively. Diethyl phthalate (DEP) was found at the highest concentrations, which ranged from 4.83 to 2250 ng/m(3) (median 152) followed by di-n-butyl phthalate, which ranged from 4.05 to 1170 ng/m(3) (median 63.3). The median inhalation exposure dose to phthalates was estimated at 0.845, 0.423, 0.203, 0.089, and 0.070 A mu g/kg-bw/d for infants, toddlers, children, teenagers, and adults, respectively. Inhalation is an important pathway of human exposure to DEP.

41. **D. H. Bennett, R. E. Moran, X. Wu, N. S. Tulve, M. S. Clifton, M. Colon, W. Weathers, A. Sjodin, R. Jones and I. Hertz-Picciotto**, **Polybrominated diphenyl ether (PBDE) concentrations and resulting exposure in homes in California: relationships among passive air, surface wipe and dust concentrations, and temporal variability** (**2015**), Journal/Indoor Air, 25, 220-229.

Polybrominated diphenyl ethers (PBDEs) are used as flame retardants in furniture foam, electronics, and other home furnishings. A field study was conducted that enrolled 139 households from California, which has had more stringent flame retardant requirements than other countries and areas. The study collected passive air, floor and indoor window surface wipes, and dust samples (investigator collected using an HVS3 and vacuum cleaner) in each home. PentaBDE and BDE209 were detected in the majority of the dust samples and many floor wipe samples, but the detection in air and window wipe samples was relatively low. Concentrations of each PBDE congener in different indoor environmental media were moderately correlated, with correlation coefficients ranging between 0.42 and 0.68. Correlation coefficients with blood levels were up to 0.65 and varied between environmental media and age group. Both investigator-collected dust and floor wipes were correlated with serum levels for a wide range of congeners. These two sample types also had a relatively high fraction of samples with adequate mass for reliable quantification. In 42 homes, PBDE levels measured in the same environmental media in the same home 1year apart were statistically correlated (correlation coefficients: 0.57-0.90), with the exception of BDE209 which was not well correlated longitudinally.

42. **H. Nakata, M. Hinosaka and H. Yanagimoto**, **Macrocyclic-, polycyclic-, and nitro musks in cosmetics, household commodities and indoor dusts collected from Japan: Implications for their human exposure** (**2015**), Journal/Ecotoxicology and Environmental Safety, 111, 248-255.

This paper reported the occurrence and concentrations of macrocyclic-, polycyclic- and nitro musks in cosmetics and household commodities collected from Japan. The high concentrations and detection frequencies of Musk T, habanolide, and exaltolides were found in commercial products, suggesting their large amounts of production and usage in Japan. Polycyclic musks, HHCB and OTNE, also showed high concentrations in cosmetics and products. The estimated dairy intakes of Musk T and HHCB by the dermal exposure to commercial products were 7.8 and 7.9 mu g/kg/day in human, respectively, and perfume and body lotion are dominant exposure sources. We also analyzed synthetic musks in house dusts. Polycyclic musks, HHCB and OTNE, showed high concentrations in samples, but macrocyclic musks were detected only in a few samples, although these types of musks were highly detected in commercial products. This is probably due to easy-degradation of macrocyclic musks in indoor environment. The dairy intakes of HHCB by dust ingestions were 0.22 ng/kg/day in human, which were approximately five orders of magnitudes lower than those of dermal absorption from commercial household commodities. (C) 2014 Elsevier Inc. All rights reserved.

43. **Y. Li, L. Chen, D. M. Ngoc, Y. P. Duan, Z. B. Lu, Z. H. Wen and X. Z. Meng**, **Polybrominated Diphenyl Ethers (PBDEs) in PM2.5, PM10, TSP and Gas Phase in Office Environment in Shanghai, China: Occurrence and Human Exposure** (**2015**), Journal/Plos One, 10, 15.

To evaluate risk via inhalation exposure of polybrominated diphenyl ethers (PBDEs) in office environment, thirty-six pairs air samples including PM2.5 (particles with aerodynamic diameter less than 2.5 mu m), PM10 (particles with aerodynamic diameter less than 10 mu m), total suspended particles (TSP) with matching gas phase were collected in office environment in Shanghai, China. The average concentrations of PM2.5, PM10 and TSP were 20.4, 27.2 and 50.3 mu g/m(3), respectively. Sigma 15PBDEs mean concentrations in PM2.5, PM10, TSP and gas phase were 51.8, 110.7, 148 and 59.6 pg/m(3), respectively. Much more PBDEs distributed in fine fractions than coarse ones. PBDEs congener profiles found in PM2.5, PM10 and TSP (dominated by BDE-209) were different from that in gas phase (dominated by the tri-to penta-BDEs). Approximately 3.20 pg/kg/d PM2.5 bound PBDEs can be inhaled into the lung; 3.62 pg/kg/d PM10-PM2.5(particles with aerodynamic diameter of 2.5-10 mu m) bound PBDEs tended to be deposited in the upper part of respiratory system, and the intake of PBDEs via gas-phase was 2.74 pg/kg/d. The exposure of PBDEs was far below the minimal risk levels (MRLs), indicating lower risk from PBDEs via inhalation in the studied office in Shanghai.

c.   Particules / biocontaminants

44. **M. Sowiak, K. Jezak, A. Kozajda, W. Sobala and I. Szadkowska-Stanczyk**, **VISIBLE FUNGI GROWTH AND DAMPNESS ASSESSED USING A QUESTIONNAIRE VERSUS AIRBORNE FUNGI, (1 -> 3)-beta-D-GLUCAN AND FUNGAL SPORE CONCENTRATIONS IN FLATS** (**2015**), Journal/International Journal of Occupational Medicine and Environmental Health, 28, 130-146.

Objectives: The study aimed at determination of the usefulness of the subjective assessment of selected signs of fungi growth in flats and microclimate parameters to indicate the actual air contamination with culturable fungi, (1 -> 3)-beta-D-glucans and fungal spores. Material and Methods: This analysis covered 22 flats, the inhabitants of which declared in a questionnaire interview the presence of the developed mycelium on solid surfaces in the flat. Air samples for determination of the culturable fungi, (1 -> 3)-beta-D-glucans and (viable and non-viable) fungal spores concentrations indoor and outdoor the flats during the heating period were collected. During bioaerosol sampling microclimate parameters were measured. Predictive models for concentrations of the tested biological agents with regard to various ways to assess fungal contamination of air in a flat (on the basis of a questionnaire or a questionnaire and microclimate measurements) were built. Results: The arithmetic means of temperature, relative humidity, CO2 concentration and air flow velocity in the flats were respectively: 20.5 degrees C, 53%, 1431.6 ppm and 0 m/s. The geometric mean concentrations of airborne fungi, (1 -> 3)-beta-D-glucans and fungal spores in these premises amounted to 2.9 x 10(2) cfu/m(3), 1.6 ng/m(3) and 5.7 x 10(3) spores/m(3), respectively. The subjective assessment of fungi growth signs and microclimate characteristics were moderately useful for evaluation of the actual airborne fungi and (1 -> 3)-beta-D-glucan concentrations (maximum percent of explained variance (VE) = 61% and 67%, respectively), and less useful in evaluation of the actual fungal spore concentrations (VE < 29%). In the case of fungi, higher usefulness was indicated of the questionnaire evaluation supported by microclimate measurements (VE = 61.2%), as compared to the evaluation only by means of a questionnaire (VE = 46.9%). Conclusions: Subjective evaluation of fungi growth signs in flats, separately or combined with microclimate

measurements, appeared to be moderately useful for quantitative evaluation of the actual air contamination with fungi and their derivatives, but more extensive studies are needed to strengthen those findings.

45. **M. Branis, P. Rezacova and M. Lazaridis**, **The effect of source type and source strength on inhaled mass of particulate matter during episodic indoor activities** (**2014**), Journal/Indoor and Built Environment, 23, 1106-1116.

A two-week campaign was performed in a naturally ventilated apartment to quantify indoor sources and to estimate the total inhaled mass of particulate matter (PM). DustTrak photometers were used to record PM2.5 concentrations continuously. Indoor activities were recorded in a detailed time-activity diary. The results showed that short episodic indoor sources influenced the indoor PM concentration for several hours and significantly affected daily average PM2.5 concentrations, indoor/outdoor ratios and indoor/outdoor correlation coefficients. Activities leading to increased PM concentrations occurred in 9% of the total time monitored, and accounted for 68% of the total PM concentration. Among the many indoor activities recorded, smoking and hair spraying were the strongest sources of fine aerosol. The outcomes of cooking episodes were the most variable in terms of duration and aerosol levels. The calculated inhaled mass corresponded to the source strength but not to the duration of the source activity. The total mass of aerosol potentially inhaled by an adult individual during the time outside the episodes was 1367 mu g and during the episodes 2895 mu g. During one hour, one person potentially inhaled approximately 36 mu g and 294 mu g of aerosol for the non-episode and the episode periods, respectively.

46. **S. H. Kim, G. R. Ahn, S. Y. Son, G. N. Bae and Y. H. Yun**, **Mold Occurring on the Air Cleaner High-Efficiency Particulate Air Filters Used in the Houses of Child Patients with Atopic Dermatitis** (**2014**), Journal/Mycobiology, 42, 286-290.

Fungi are the known sources of irritation associated with atopic diseases (e.g., asthma, allergic rhinoconjunctivitis, and atopic eczema). To quantitatively estimate their presence in the indoor environment of atopic dermatitis-inflicted child patient's houses (ADCPHs), the high-efficiency particulate air (HEPA) filters installed inside the air cleaners of three different ADCPHs were investigated for the presence of mold. The air cleaner HEPA filters obtained from the three different ADCPHs were coded as HEPA-A, -B, and -C, respectively, and tested for the presence of mold. The colony forming units (CFUs) corresponding to the HEPA-A, -B, and -C filters were estimated to be 6.51 x 10(2) +/- 1.50 x 10(2) CFU/cm(2), 8.72 x 10(2) +/- 1.69 x 10(2) CFU/cm(2), and 9.71 x 10(2) +/- 1.35 x 10(2) CFU/cm(2), respectively. Aspergillus, Penicillium, Alternaria, Cladosporium, Trichoderma, and other fungal groups were detected in the 2,494 isolates. The distribution of these fungal groups differed among the three filters. Cladosporium was the major fungal group in filters HEPA-A and -C, whereas Penicillium was the major fungal group in the filter HEPA-B. Nine fungal species, including some of the known allergenic species, were identified in these isolates. Cladosporium cladosporioides was the most common mold among all the three filters. This is the first report on the presence of fungi in the air cleaner HEPA filters from ADCPHs in Korea.

47. **P. F. Rosenbaum, J. A. Crawford, A. Hunt, S. J. Vesper and J. L. Abraham**, **Environmental Relative Moldiness Index and Associations with Home Characteristics and Infant Wheeze** (**2015**), Journal/Journal of Occupational and Environmental Hygiene, 12, 29-36.

Possible relationships between mold contamination, as described by the Environmental Relative Moldiness Index (ERMI), home characteristics, and the development of wheeze in

the first year of life were evaluated among a cohort of urban infants (n = 103) in Syracuse, New York. Pregnant women with a history of asthma were recruited in 2001-2002 for the "Assessment of Urban Dwellings for Indoor Toxics" (AUDIT) study. When the infants were approximately 3 months of age, a home inspection was carried out and indoor environmental samples collected, including vacuumed house dust. ERMI levels in the Syracuse cohort homes were higher than the U.S. average, with an overall mean of 11.4. ERMI levels were significantly higher in homes with visible water problems (p = 0.023) and visiblemold (p = 0.023). ERMI levels in apartments were significantly lower than the values measured in houses (p = 0.0003). While infants experiencing wheeze (38%) tended to live in homes with higher ERMI values than those without wheeze (ERMI values of 12.3 and 10.9, respectively), the differences did not reach statistical significance. A subset analysis limited to infants with living room samples who remained in the same home during the study (n = 25) was suggestive of an association between higher ERMI values and wheeze (p = 0.10). In summary, the ERMI is a standardized metric which allows for comparison of moldiness levels in homes across studies and regions in the United States. ERMI levels in Syracuse homes were skewed to the high end of the national scale. Higher ERMI levels were indicators of water problems, mold, and type of housing.

II.2 Transports

Rubrique N°9

48. **A. Carteni, F. Cascetta and S. Campana**, **Underground and ground-level particulate matter concentrations in an Italian metro system** (**2015**), Journal/Atmospheric Environment, 101, 328-337.

All around the world, many studies and experimental results have assessed elevated concentrations of Particulate Matter (PM) in underground metro systems, with non-negligible implications for human health due to protracted exposure to fine particles. Starting from this consideration, an intensive particulate sampling campaign was carried out in January 2014 measuring the PM concentrations in the Naples (Italy) Metro Line 1, both at station platforms and inside trains. Naples Metro Line 1 is about 18 km long, with 17 stations (3 ground-level and 14 below-ground ones). Experimental results show that the average PM10 concentrations measured in the underground station platforms range between 172 and 262 mu g/m(3) whilst the average PM2.5 concentrations range between 45 and 60 mu/m(3). By contrast, in ground-level stations no significant difference between stations platforms and urban environment measurements was observed. Furthermore, a direct correlation between trains passage and PM concentrations was observed, with an increase up to 42% above the average value. This correlation is possibly caused by the re-suspension of the particles due to the turbulence induced by trains. The main original finding was the real-time estimations of PM levels inside the trains travelling both in ground-level and underground sections of Line 1. The results show that high concentrations of both PM10 (average values between 58 mu g/m(3) and 138 mu g/m(3)) and PM2.5 (average values between 18 mu g/m(3) and 36 mu g/m(3)) were also measured inside trains. Furthermore, measurements show that windows left open on trains caused the increase in PM concentrations inside trains in the underground section, while in the ground-level section the clean air entering the trains produced an environmental "washing effect". Finally, it was estimated that every passenger spends on average about 70 min per day exposed to high levels of PM. (C) 2014 Elsevier Ltd. All rights reserved.

49. **M. H. Y. Leung, D. Wilkins, E. K. T. Li, F. K. F. Kong and P. K. H. Lee**, **Indoor-Air Microbiome in an Urban Subway Network: Diversity and Dynamics** (**2014**), Journal/Applied and Environmental Microbiology, 80, 6760-6770.

Subway systems are indispensable for urban societies, but microbiological characteristics of subway aerosols are relatively unknown. Previous studies investigating microbial compositions in subways employed methodologies that underestimated the diversity of microbial exposure for commuters, with little focus on factors governing subway air microbiology, which may have public health implications. Here, a culture-independent approach unraveling the bacterial diversity within the urban subway network in Hong Kong is presented. Aerosol samples from multiple subway lines and outdoor locations were collected. Targeting the 16S rRNA gene V4 region, extensive taxonomic diversity was found, with the most common bacterial genera in the subway environment among those associated with skin. Overall, subway lines harbored different phylogenetic communities based on alpha- and beta- diversity comparisons, and closer inspection suggests that each community within a line is dependent on architectural characteristics, nearby outdoor microbiomes, and connectedness with other lines. Microbial diversities and assemblages also varied depending on the day sampled, as well as the time of day, and changes in microbial communities between peak and nonpeak commuting hours were attributed largely to increases in skin-associated genera in peak samples. Microbial diversities within the subway were influenced by temperature and relative humidity, while carbon dioxide levels showed a positive correlation with abundances of commuter-associated genera. This Hong Kong data set and communities from previous studies conducted in the United States formed distinct community clusters, indicating that additional work is required to unravel the mechanisms that shape subway microbiomes around the globe.

II.3 Bureaux

Rubrique N°10

50. **J. Kowalska, M. Szewczynska and M. Posniak**, **Measurements of chlorinated volatile organic compounds emitted from office printers and photocopiers** (**2015**), Journal/Environmental Science and Pollution Research, 22, 5241-5252.

Office devices can release volatile organic compounds (VOCs) partly generated by toners and inks, as well as particles of paper. The aim of the presented study is to identify indoor emissions of volatile halogenated organic compounds into the office workspace environment. Mixtures of organic pollutants emitted by seven office devices, i.e. printers and copiers, were analyzed by taking samples in laboratory conditions during the operation of these appliances. Tests of volatile organic compound emissions from selected office devices were conducted in a simulated environment (test chamber). Samples of VOCs were collected using three-layered thermal desorption tubes. Separation and identification of organic pollutant emissions were made using thermal desorption combined with gas chromatography coupled to mass spectrometry. Test chamber studies indicated that operation of the office printer and copier would contribute to the significant concentration level of VOCs in typical office indoor air. Among the determined volatile halogenated compounds, only chlorinated organic compounds were identified, inter alia: trichloroethylene - carcinogenic - and tetrachloroethylene - possibly carcinogenic to human. The results show that daily exposure of an office worker to chemical factors released by the tested printing and copying units can be variable in terms of concentrations of VOCs. The highest emissions in the test chamber during printing were measured for ethylbenzene up to 41.3 mu g m(-3), xylenes up to 40.5 mu g m(-3) and in case of halogenated compounds the highest concentration for chlorobenzene was 6.48 mu g m(-3). The study included the comparison of chamber

concentrations and unit-specific emission rates of selected VOCs and the identified halogenated compounds. The highest amount of total VOCs was emitted while copying with device D and was rated above 1235 mu g m(-3) and 8400 mu g unit(-1) h(-1) on average.

51. **A. W. Norgaard, V. Kofoed-Sorensen, C. Mandin, G. Ventura, R. Mabilia, E. Perreca, A. Cattaneo, A. Spinazze, V. G. Mihucz, T. Szigeti, Y. de Kluizenaar, H. J. M. Cornelissen, M. Trantallidi, P. Carrer, I. Sakellaris, J. Bartzis and P. Wolkoff**, **Ozone-initiated Terpene Reaction Products in Five European Offices: Replacement of a Floor Cleaning Agent** (**2014**), Journal/Environmental Science & Technology, 48, 13331-13339.

Cleaning agents often emit terpenes that react rapidly with ozone. These ozone-initiated reactions, which occur in the gas-phase and on surfaces, produce a host of gaseous and particulate oxygenated compounds with possible adverse health effects in the eyes and airways. Within the European Union (EU) project OFFICAIR, common ozone-initiated reaction products were measured before and after the replacement of the regular floor cleaning agent with a preselected low emitting floor cleaning agent in four offices located in four EU countries. One reference office in a fifth country did not use any floor cleaning agent. Limonene, a-pinene, 3-carene, dihydromyrcenol, geraniol, linalool, and a-terpineol were targeted for measurement together with the common terpene oxidation products formaldehyde, 4-acetyl-l-methylcyclohexene (4-AMCH), 3-isopropenyl-6-oxo-heptanal (IPOH), 6-methyl-5-heptene-2-one, (6-MHO), 4-oxopentanal (4-0PA), and dihydrocarvone (DHC). Two-hour air samples on Tenax TA and DNPH cartridges were taken in the morning, noon, and in the afternoon and analyzed by thermal desorption combined with gas chromatography/mass spectrometry and HPLC/UV analysis, respectively. Ozone was measured in all sites. All the regular cleaning agents emitted terpenes, mainly limonene and linalool. After the replacement of the cleaning agent, substantially lower concentrations of limonene and formaldehyde were observed. Some of the oxidation product concentrations, in particular that of 4-0PA, were also reduced in line with limonene. Maximum 2 h averaged concentrations of formaldehyde, 4-AMCH, 6-MIHO, and IPOH would not give rise to acute eye irritation-related symptoms in office workers; similarly, 6-AMCH, DHC and 4-0PA would not result in airflow limitation to the airways.

II.4 ERP

Rubrique N°11

52. **N. Mishra, J. Bartsch, G. A. Ayoko, T. Salthammer and L. Morawska**, **Volatile Organic Compounds: Characteristics, distribution and sources in urban schools** (**2015**), Journal/Atmospheric Environment, 106, 485-491.

Long term exposure to organic pollutants, both inside and outside school buildings may affect children's health and influence their learning performance. Since children spend significant amount of time in school, air quality, especially in classrooms plays a key role in determining the health risks associated with exposure at schools. Within this context, the present study investigated the ambient concentrations of Volatile Organic Compounds (VOCs) in 25 primary schools in Brisbane with the aim to quantify the indoor and outdoor VOCs concentrations, identify VOCs sources and their contribution, and based on these; propose mitigation measures to reduce VOCs exposure in schools. One of the most important findings is the occurrence of indoor sources, indicated by the I/O ratio >1 in 19 schools. Principal Component Analysis with Varimax rotation was used to identify common sources of VOCs and source contribution was calculated using an Absolute Principal Component Scores technique. The result showed that outdoor 47% of VOCs were contributed by petrol vehicle exhaust but the overall cleaning products had the highest

contribution of 41% indoors followed by air fresheners and art and craft activities. These findings point to the need for a range of basic precautions during the selection, use and storage of cleaning products and materials to reduce the risk from these sources. (C) 2014 Elsevier Ltd. All rights reserved.

53. **M. Viana, I. Rivas, X. Querol, A. Alastuey, M. Alvarez-Pedrerol, L. Bouso, C. Sioutas and J. Sunyer**, **Partitioning of trace elements and metals between quasi-ultrafine, accumulation and coarse aerosols in indoor and outdoor air in schools** (**2015**), Journal/Atmospheric Environment, 106, 392-401.

Particle size distribution patterns of trace elements and metals across three size fractions (<0.25 mu m, quasi-ultrafine particles, q-UF; 0.25-2.5 mu m, accumulation particles; 2.5-10 mu m, coarse particles) were analysed in indoor and outdoor air at 39 primary schools across Barcelona (Spain). Special attention was paid to emission sources in each particle size range. Results evidenced the presence in q-UF particles of high proportions of elements typically found in coarse PM (Ca, Al, Fe, Mn or Na), as well as several potentially health-hazardous metals (Mn, Cu, Sn, V, Pb). Modal shifts (e.g., from accumulation to coarse or q-UF particles) were detected when particles infiltrated indoors, mainly for secondary inorganic aerosols. Our results indicate that the location of schools in heavily trafficked areas increases the abundance of q-UF particles, which infiltrate indoors quite effectively, and thus may impact children exposure to these health-hazardous particles. (C) 2014 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/3.0/).

54. **N. Muscatiello, A. McCarthy, C. Kielb, W. H. Hsu, S. A. Hwang and S. Lin**, **Classroom conditions and CO2 concentrations and teacher health symptom reporting in 10 New York State Schools** (**2015**), Journal/Indoor Air, 25, 157-167.

This study assessed the relationship between teacher-reported symptoms and classroom carbon dioxide (CO_2) concentrations. Previous studies have suggested that poor indoor ventilation can result in higher levels of indoor pollutants, which may affect student and teacher health. Ten schools (9 elementary, 1 combined middle/high school) in eight New York State school districts were visited over a 4-month period in 2010. Carbon dioxide concentrations were measured in classrooms over 48-h, and teachers completed surveys assessing demographic information and self-reported symptoms experienced during the current school year. Data from 64 classrooms (ranging from 1 to 9 per school) were linked with 68 teacher surveys (for four classrooms, two surveys were returned). Overall, approximately 20% of the measured classroom CO_2 concentrations were above 1000 parts per million (ppm), ranging from 352 to 1591ppm. In multivariate analyses, the odds of reporting neuro-physiologic (i.e., headache, fatigue, difficulty concentrating) symptoms among teachers significantly increased (OR=1.30, 95% CI=1.02-1.64) for every 100ppm increase in maximum classroom CO_2 concentrations and were non-significantly increased in classrooms with above-median proportions of CO_2 concentrations greater than 1000ppm (OR=2.26, 95% CI=0.72-7.12).

55. **L. Chatzidiakou, D. Mumovic and A. Summerfield**, **Is CO2 a good proxy for indoor air quality in classrooms? Part 1: The interrelationships between thermal conditions, CO2 levels, ventilation rates and selected indoor pollutants** (**2015**), Journal/Building Services Engineering Research & Technology, 36, 129-161.

Current indoor air quality (IAQ) guidelines in school buildings are framed around thermal conditions, carbon dioxide (CO_2) levels and corresponding ventilation rates without

considering specific indoor pollution levels. Drawing on detailed monitoring data from a sample of 18 classrooms from six London schools, the aim of this paper is to highlight behavioural and environmental factors that affect pollution levels in classrooms, and evaluate the adequacy of CO_2 as an overall predictor for IAQ using multilevel modelling. Together with elimination of indoor emission sources, keeping the temperatures below 26?, and preferably below 22? depending on season, may limit total volatile organic compounds below thresholds associated with sensory irritations. The models suggested that after removing dust reservoirs from the classrooms, lowering average indoor CO_2 levels below 1000ppm by increasing ventilation rates can limit indoor airborne particulate matter concentrations below recommended annual WHO 2010 guidelines. Uncontrolled infiltration rates may increase indoor NO_2 levels and microbial counts of fungal and bacterial groups, whose presence is associated with wet and moist materials. Overall, indoor CO_2 levels were a useful proxy for indoor investigations as they can prevent overheating, dilute pollutants with indoor sources and purge concentrations of airborne particles; however, they were a poor predictor of traffic related pollutants. Practical implications of the findings on the UK policy and building design industry are discussed. Practical application: Driven by the growing population, and many years of intensive use, the UK building stock is in need of rapid expanding, extensive refurbishment and maintenance. However, local authorities lack the money for comprehensive and specialist renovations. The recommendations presented in this paper take into account specific needs and possibilities, and target building designers, engineers and occupants involved with daily operation and management of school buildings. Timely control of ventilation and heating systems, informed selection of construction materials, interior finishing and elimination of indoor sources may improve IAQ of school classrooms.

56. **L. Chatzidiakou, D. Mumovic and A. Summerfield**, **Is CO2 a good proxy for indoor air quality in classrooms? Part 2: Health outcomes and perceived indoor air quality in relation to classroom exposure and building characteristics** (**2015**), Journal/Building Services Engineering Research & Technology, 36, 162-181.

The aim of this paper is to investigate whether keeping indoor thermal conditions and carbon dioxide (CO_2) levels within the current guideline values can provide a healthy and comfortable school environment. The study was organised as a longitudinal investigation over an academic year using a cohort of 376 students aged 9 to 11 (response rate: 87%) attending 15 classrooms in five London primary schools. The prevalence of asthmatic symptoms and asthma attacks was significantly higher among children attending urban schools (10.2%) than suburban schools (1.5%), and was significantly related to exposure to higher nitrogen dioxide (NO_2) concentrations (odds ratio: 1.11, 95% confidence interval: 1.00-1.19). Self-reported dermal, mucosal, respiratory and general symptoms were 18.5%, 60.7%, 28.2% and 43.6% respectively in the heating season, and decreased in the non-heating season. Infiltration rates were negatively associated with prevalence and incidence of all sick building syndrome symptoms. Exposure to traffic-related pollutants, such NO_2, ozone (O_3) and tetrachloroethylene (T4CE), associated with mucosal symptoms, also increased dissatisfaction with indoor air quality (IAQ) and, therefore, perceived IAQ might be a first indication of exposure. Among targeted microbial counts, only Trichoderma viride remained significant predictors of satisfaction with IAQ even at low concentrations. The study provides evidence that simultaneous provision for limiting indoor CO_2 levels and thermal conditions below current guidelines (e.g. below 1000ppm and 26? or 22? depending on season) may improve perceived IAQ. This paper stresses the need to go beyond current regulations to investigate concentrations of specific pollutants to ensure a healthy school environment, and closes with a section on the practical implications on the UK policy and the building design industry. Practical application: The findings highlight the role and responsibility of stakeholders, from regulators to designers and school authorities, to account for the external environment and take the steps needed to ensure that schools provide a

healthy indoor environment for their students. The recommendations focus on the need to decrease outdoor pollution levels in the school vicinity, thus improving health of the students and reducing the prevalence of respiratory illness. Building designers and engineers shall adopt an integrated approach for the simultaneous provision of adequate thermal conditions and IAQ in classrooms.

57. **F. Amato, I. Rivas, M. Viana, T. Moreno, L. Bouso, C. Reche, M. Alvarez-Pedrerol, A. Alastuey, J. Sunyer and X. Querol**, **Sources of indoor and outdoor PM2.5 concentrations in primary schools** (**2014**), Journal/Science of the Total Environment, 490, 757-765.

Children spend a third of their day in the classroom, where air pollution levels may differ substantially from those outdoors due to specific indoor sources. Air pollution exposure assessments based on atmospheric particle mass measured outdoors may therefore have little to do with the daily PM dose received by school children. This study aims to investigate outdoor and indoor sources of PM2.5 measured at 39 primary schools in Barcelona during 2012. On average 47% of indoor PM2.5 measured concentrations was found to be generated indoors due to continuous resuspension of soil particles (13%) and a mixed source (34%) comprising organic (skin flakes, clothes fibers, possible condensation of VOCs) and Ca-rich particles (from chalk and building deterioration). Emissions from seven outdoor sources penetrated easily indoors being responsible for the remaining 53% of measured PM2.5 indoors. Un3paved playgrounds were found to increase mineral contributions in classrooms by 5-6 mu g/m(3) on average with respect to schools with paved playgrounds. Weekday traffic contributions varied considerably across Barcelona within ranges of 1-14 mu g/m(3) outdoor and 1-10 mu g/m(3) indoor. Indoors, traffic contributions were significantly higher (more than twofold) for classrooms with windows oriented directly to the street, rather than to the interior of the block or to playgrounds. This highlights the importance of urban planning in order to reduce children's exposure to traffic emissions. (C) 2014 Elsevier B.V. All rights reserved.

58. **P. Wargocki and N. A. F. Da Silva**, **Use of visual CO2 feedback as a retrofit solution for improving classroom air quality** (**2015**), Journal/Indoor Air, 25, 105-114.

Carbon dioxide (CO2) sensors that provide a visual indication were installed in classrooms during normal school operation. During 2-week periods, teachers and students were instructed to open the windows in response to the visual CO2 feedback in 1week and open them, as they would normally do, without visual feedback, in the other week. In the heating season, two pairs of classrooms were monitored, one pair naturally and the other pair mechanically ventilated. In the cooling season, two pairs of naturally ventilated classrooms were monitored, one pair with split cooling in operation and the other pair with no cooling. Classrooms were matched by grade. Providing visual CO2 feedback reduced CO2 levels, as more windows were opened in this condition. This increased energy use for heating and reduced the cooling requirement in summertime. Split cooling reduced the frequency of window opening only when no visual CO2 feedback was present.

59. **T. Cecchi**, **Identification of representative pollutants in multiple locations of an Italian school using solid phase micro extraction technique** (**2014**), Journal/Building and Environment, 82, 655-665.

Background: Good indoor air quality is crucial for teachers and students attendance, performance, and health. Limited information is available as regards typical volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) found in school indoor air. It is urgent to find out which are the main atmospheric pollutants to which students and staff are exposed. Objectives: The aim of this study was to screen, speciate, and identify the

school indoor and outdoor VOCs and, for the very first time, SVOCs, in order to find out the most representative airborne model pollutants. Methods: Solid phase micro extraction technique (SPME) and gas chromatography-mass spectrometry (GC-MS) were used to sample and analyse air of 16 school locations. Results: A very high number (119) of school airborne contaminants have been identified. They may have both an indoor and an outdoor origin. Pollutants with a clear indoor source, such as 2-butoxy-ethanol, 2-ethyl-1-hexanol, terpenes and terpenoids, butylated-hydroxytoluene, lilial, benzaldehyde, and phthalates, are highly eligible markers of the indoor air pollution. Even if none of them are carcinogenic or mutagenic, they play a role in the arising of the sick building syndrome (SBS) symptoms. Conclusions: Since many of the airborne pollutants have indoor sources, adequate ventilation can prevent excess indoor exposure to pollutants only if the outdoor pollutant levels are low; the most effective way to reduce exposure is to eliminate their origins. SPME is a highly eligible sampling technique for pollutants speciation in surveillance programs. (C) 2014 Elsevier Ltd. All rights reserved.

II.5 Autres lieux de vie / loisirs
Rubrique N°12

a.   Piscines

60. **M. Z. Afifi and E. R. Blatchley**, **Seasonal dynamics of water and air chemistry in an indoor chlorinated swimming pool** (**2015**), Journal/Water Research, 68, 771-783.

Although swimming is known to be beneficial in terms of cardiovascular health, as well as for some forms of rehabilitation, swimming is also known to present risks to human health, largely in the form of exposure to microbial pathogens and disinfection byproducts (DBPs). Relatively little information is available in the literature to characterize the seasonal dynamics of air and water chemistry in indoor chlorinated swimming pools. To address this issue, water samples were collected five days per week from an indoor chlorinated swimming pool facility at a high school during the academic year and once per week during summer over a fourteen-month period. The samples were analyzed for free and combined chlorine, urea, volatile DBPs, pH, temperature and total alkalinity. Membrane Introduction Mass Spectrometry (MIMS) was used to identify and measure the concentrations of eleven aqueous-phase volatile DBPs. Variability in the concentrations of these DBPs was observed. Factors that influenced variability included bather loading and mixing by swimmers. These compounds have the ability to adversely affect water and air quality and human health. A large fraction of the existing literature regarding swimming pool air quality has focused on trichloramine (NCl_3). For this work, gas-phase NCl_3 was analyzed by an air sparging-DPD/KI method. The results showed that gas-phase NCl_3 concentration is influenced by bather loading and liquid-phase NCl_3 concentration. Urea is the dominant organic-N compound in human urine and sweat, and is known to be an important precursor for producing NCl_3 in swimming pools. Results of daily measurements of urea indicated a link between bather load and urea concentration in the pool. (C) 2014 Elsevier Ltd. All rights reserved.

61. **F. Gerardin, A. Cloteaux and N. Midoux**, **Modeling of variations in nitrogen trichloride concentration over time in swimming pool water** (**2015**), Journal/Process Safety and Environmental Protection, 94, 452-462.

In water, chlorine reacts with nitrogen-containing compounds to produce disinfection by-products such as nitrogen trichloride which induces ocular and respiratory irritations in swimming pool workers. This study proposes a model to predict variations in NCl_3

concentration over time in a traditional indoor swimming pool as a function of its operating parameters and attendance. The model was developed taking into consideration the reaction mechanisms, thermodynamic equilibria, physico-chemical properties, and transfer mechanisms occurring at the pool's surface. This model was validated through a robust series of experiments over two days and two nights in a real swimming pool. The model was found to satisfactorily predict variations over time in the concentrations of the chemical species investigated, including nitrogen trichloride. The work presented constitutes a first step to extend the model at different swimming pools. This approach may also be used to study the influence of the main operating parameters and to evaluate the impact of setting up water treatment systems on nitrogen trichloride concentration. (C) 2014 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.

62. **F. Soltermann, S. Canonica and U. von Gunten**, **Trichloramine reactions with nitrogenous and carbonaceous compounds: Kinetics, products and chloroform formation** (**2015**), Journal/Water Research, 71, 318-329.

Trichloramine is a hazardous disinfection by-product that is of particular relevance in indoor swimming pools. To better understand its fate in pool waters, apparent second order rate constants (k_{app}) at pH 7 for its reaction with several model compounds were determined. k_{app} values at pH 7 for nitrogenous compounds were found to increase in the following order: ammonia similar to amides (similar to 10^{-2}-10^{-1} M-1 s(-1)) < primary amines (similar to 10^{-2}-10^{0} M-1 s(-1)) < relevant body fluid compounds (L-histidine, creatinine) (similar to 10^{0}-10^{1} M-1 s(-1)) < secondary amines (similar to 10^{1} -10^{2} M-1 s(-1)) < trimethylamine (similar to 10^{3} M-1 s(-1)). k_{app} values at pH 7 of trichloramine with hydroxylated aromatic compounds (similar to 10^{2}-10^{5} M-1 s(-1)) are higher than for the nitrogenous compounds and depend on the number and position of the hydroxyl groups (phenol < hydroquinone < catechol < resorcinol). The measurement of k_{app} as a function of pH revealed that mainly the deprotonated species react with trichloramine. The reaction of trichloramine with Suwannee River and Pony Lake fulvic acid standards showed a decrease of their reactivity upon chlorination, which can be related to the electron donating capacity and the SUVA(254). Chlorinated nitrogenous compounds (e.g. uric acid) also have a reduced reactivity with trichloramine. Hence, the residual chlorine in pool water hinders a fast consumption of trichloramine. This explains why trichloramine degradation in pool water is lower than expected from the reactivity with the estimated bather input. Trichloramine also has the potential to form secondary disinfection by-products such as chlorinated aromatic compounds or chloroform by electron transfer or Cl+-transfer reactions. The chloroform formation from the reaction of trichloramine with resorcinol occurs with a similar yield and rate as for chlorination of resorcinol. Since the trichloramine concentration in pool water is commonly about one order of magnitude lower than the free chlorine concentration, its contribution to the disinfection by-product formation is assumed to be minor in most cases but might be relevant for few precursors (e.g. phenols) that react faster with trichloramine than with free chlorine. (C) 2014 Elsevier Ltd. All rights reserved.

b.   **Autres**

63. **A. J. Buczynska, A. Krata, R. Van Grieken, A. Brown, G. Polezer, K. De Wael and S. Potgieter-Vermaak**, **Composition of PM2.5 and PM1 on high and low pollution event days and its relation to indoor air quality in a home for the elderly** (**2014**), Journal/Science of the Total Environment, 490, 134-143.

Many studies probing the link between air quality and health have pointed towards associations between particulate matter (PM) exposure and decreased lung function,

aggravation of respiratory diseases like asthma, premature death and increased hospitalisation admissions for the elderly and individuals with cardiopulmonary diseases. Of recent, it is believed that the chemical composition and physical properties of PM may contribute significantly to these adverse health effects. As part of a Belgian Science Policy project ("Health effects of particulate matter in relation to physical-chemical characteristics and meteorology"), the chemical composition (elemental and ionic compositions) and physical properties (PM mass concentrations) of PM were investigated, indoors and outdoors of old age homes in Antwerp. The case reported here specifically relates to high versus normal/low pollution event periods. PM mass concentrations for PM1 and PM2.5 fractions were determined gravimetrically after collection via impaction. These same samples were hence analysed by EDXRF spectrometry and IC for their elemental and ionic compositions, respectively. During high pollution event days, PM mass concentrations inside the old age home reached 53 mu g m(-3) and 32 mu g m(-3) whilst outside concentrations were 101 mu gm(-3) and 46 mu g m(-3) for PM2.5 and PM1, respectively. The sum of nss-sulphate, nitrate and ammonium, dominate the composition of PM, and contribute the most towards an increase in the PM during the episode days constituting 64% of ambient PM2.5 (52 mu g m(-3)) compared to 39% on non-episode days (10 mu g m(-3)). Other PM components, such as mineral dust, sea salt or heavy metals were found to be considerably higher during PM episodes but relatively less important. Amongst heavy metals Zn and Pb were found at the highest concentrations in both PM2.5 and PM1. Acid-base ionic balance equations were calculated and point to acidic aerosols during event days and acidic to alkaline aerosols during non-event days. No significant sources of indoor pollutants could be identified inside the old-age home as high correlations were found between outdoor and indoor PM, confirming mainly the outdoor origin of indoor air. (C) 2014 Elsevier B.V. All rights reserved.

64. **Y. Xu, Y. R. Liang, J. R. Urquidi and J. A. Siegel**, **Phthalates and polybrominated diphenyl ethers in retail stores** (**2014**), Journal/Atmospheric Environment, 87, 53-64.

Retail stores contain a wide range of products that can emit a variety of indoor pollutants. Among these chemicals, phthalate esters and polybrominated diphenyl ethers (PBDEs) are two important categories, because they are extensively used as additives in consumer products and associated with serious health concerns. This study measured six phthalate and 14 PBDE compounds inside of 12 retail stores in Texas and Pennsylvania, U.S. Phthalates and PBDEs were widely found in the retail environment, indicating that they are ubiquitous indoor air pollutants. DEP. DnBP, and DEHP were the most abundant phthalates, with DnBP showing the highest concentration (0.23 +/- 0.36 mu g m(-3)). PBDEs were dominated by BDE-28, -99, and -209, having concentrations as high as 0.85 +/- 1.99 ng m(-3) (BDE-99). The levels of phthalates and PBDEs measured in this study are comparable to concentrations found in previous investigations of residential buildings, with phthalates showing lower concentrations and PBDEs exhibiting higher concentrations in retail stores. The potential co-occurrence of phthalates was not as strong as that of PBDEs, suggesting that phthalates might have more diverse sources. Whole building emission rates were calculated and showed similar patterns of variations as indoor air concentrations, suggestion the diversity of indoor sources of phthalates and PBDEs in retail environments. (C) 2014 Elsevier Ltd. All rights reserved.

II.6 Ventilation

Rubrique N°13

65. **P. Azimi, D. Zhao and B. Stephens**, **Estimates of HVAC filtration efficiency for fine and ultrafine particles of outdoor origin** (**2014**), Journal/Atmospheric Environment, 98, 337-346.

This work uses 194 outdoor particle size distributions (PSDs) from the literature to estimate single-pass heating, ventilating, and air-conditioning (HVAC) filter removal efficiencies for PM2.5 and ultrafine particles (UFPs: <100 nm) of outdoor origin. The PSDs were first fitted to tri-modal lognormal distributions and then mapped to size-resolved particle removal efficiency of a wide range of HVAC filters identified in the literature. Filters included those with a minimum efficiency reporting value (MERV) of 5, 6, 7, 8, 10, 12, 14, and 16, as well as HEPA filters. We demonstrate that although the MERV metric defined in ASHRAE Standard 52.2 does not explicitly account for UFP or PM2.5 removal efficiency, estimates of filtration efficiency for both size fractions increased with increasing MERV. Our results also indicate that outdoor PSD characteristics and assumptions for particle density and typical size-resolved infiltration factors (in the absence of HVAC filtration) do not drastically impact estimates of HVAC filter removal efficiencies for PM2.5. The impact of these factors is greater for UFPs; however, they are also somewhat predictable. Despite these findings, our results also suggest that MERV alone cannot always be used to predict UFP or PM2.5 removal efficiency given the various size-resolved removal efficiencies of different makes and models, particularly for MERV 7 and MERV 12 filters. This information improves knowledge of how the MERV designation relates to PM2.5 and UFP removal efficiency for indoor particles of outdoor origin. Results can be used to simplify indoor air quality modeling efforts and inform standards and guidelines. (C) 2014 Elsevier Ltd. All rights reserved.

66. **A. Jurelionis, L. Gagyte, T. Prasauskas, D. Ciuzas, E. Krugly, L. Seduikyte and D. Martuzevicius**, **The impact of the air distribution method in ventilated rooms on the aerosol particle dispersion and removal: The experimental approach** (**2015**), Journal/Energy and Buildings, 86, 305-313.

The ventilation strategy, air distribution method and air change rate may affect building energy consumption significantly. However, this strategy is also related to contaminant dispersion, its removal efficiency and the risk of cross-infection in buildings. In this study, the effects of air distribution methods on aerosol particle behaviour in a ventilated room have been experimentally tested. Experiments were conducted in a full-scale test chamber with the source of contaminant (a nebulised solution of sodium chloride) positioned at the air supply and air exhaust sides. Displacement ventilation and mixing ventilation with one-way and four-way air supply through ceiling diffusers were tested at I, 2,3 and 4 air changes per hour. The concentration of particles was monitored within 10 min after the injection using six optical particle counters located in one plane section of the room. Aerosol particle decay was used for calculating the age of the air and analysing the ventilation efficiency. Computational fluid dynamics (CFD) predictions were performed to determine the spatial particle dispersion in the room and were compared to the results of the experiment. Experimental results showed that at lower air change rates, one-way mixing ventilation directed particles towards air exhaust diffusers more efficiently, while four-way mixing ventilation enabled more particles to remain airborne. At higher air exchange rates (3 and 4 ach), mixing ventilation with one-way air supply prevented aerosol particle transport to the opposite side of the room. The displacement air distribution appeared to be rather inefficient in the removal of particles from the chamber, which was reflected by the relatively high age of the air (of average 16.7 s

at 3-4 ach) compared to the mixing ventilation (of average 9.9 s at 3-4 ach). (C) 2014 Elsevier B.V. All rights reserved.

67. **P. V. Dorizas, M. N. Assimakopoulos, C. Helmis and M. Santamouris**, **An integrated evaluation study of the ventilation rate, the exposure and the indoor air quality in naturally ventilated classrooms in the Mediterranean region during spring** (**2015**), Journal/Science of the Total Environment, 502, 557-570.

Ventilation rates and indoor air pollutants have been extensively monitored in nine naturally ventilated primary schools of Athens, Greece during spring. The ventilation rates and pollutant levels were studied during the teaching and non-teaching periods and ventilation profiles were created for each of the schools. The median ventilation rates per school ranged between 0.7 and 8 ACH while the average ventilation rate in all schools (11.7 l/s/p) was greater than the minimum recommended rates by ASHRAE for school classrooms. The average carbon dioxide (CO_2) concentrations per school varied between 893 and 2082 ppm, while the majority of the cases were slightly above the recommended limit values. CO_2 concentrations were also positively correlated to the number of students and negatively correlated to the ventilation rates. Particles of several size ranges (PM10, PM5, PM2.5, PM1, PM0.5 and UFP) were also measured and analyzed. PM10 concentrations exceeded the recommended limit values by more than 10 times for the majority of the cases. There were also many cases that the PM2.5 concentrations exceeded their limit values. PM concentrations were significantly affected by the ventilation rates and the presence of students. All of the measured particle sizes were greater during teaching than the non-teaching hours. For most of the cases the indoor to outdoor (I/O) concentrations ratios of PM10 and PM2.5 were much greater than one, indicating that the indoor environment was being mostly affected by indoor sources instead of the outdoor air. Furthermore it was found that chalk and marker boards' usage significantly affect indoor pollutant concentrations. Overall, the measured levels of exposure were for most of the cases greater than the recommended guideline values due to the intense presence of indoor pollution sources, even though the ventilation rates were in general satisfactory. (C) 2014 Elsevier B.V. All rights reserved.

II.7 Modélisation

Rubrique N°14

a.   Radon

68. **G. Kropat, F. Bochud, M. Jaboyedoff, J. P. Laedermann, C. Murith, M. Palacios and S. Baechler**, **Predictive analysis and mapping of indoor radon concentrations in a complex environment using kernel estimation: An application to Switzerland** (**2015**), Journal/Science of the Total Environment, 505, 137-148.

Purpose: The aim of this study was to develop models based on kernel regression and probability estimation in order to predict and map IRC in Switzerland by taking into account all of the following: architectural factors, spatial relationships between the measurements, as well as geological information. Methods: We looked at about 240000 IRC measurements carried out in about 150000 houses. As predictor variables we included: building type, foundation type, year of construction, detector type, geographical coordinates, altitude, temperature and lithology into the kernel estimation models. We developed predictive maps as well as a map of the local probability to exceed 300 Bq/m(3). Additionally, we developed a map of a confidence index in order to estimate the reliability of the probability map. Results:

Our models were able to explain 28% of the variations of IRC data. All variables added information to the model. The model estimation revealed a bandwidth for each variable, making it possible to characterize the influence of each variable on the IRC estimation. Furthermore, we assessed the mapping characteristics of kernel estimation overall as well as by municipality. Overall, our model reproduces spatial IRC patterns which were already obtained earlier. On the municipal level, we could show that our model accounts well for IRC trends within municipal boundaries. Finally, we found that different building characteristics result in different IRC maps. Maps corresponding to detached houses with concrete foundations indicate systematically smaller IRC than maps corresponding to farms with earth foundation. Conclusions: IRC mapping based on kernel estimation is a powerful tool to predict and analyze IRC on a large-scale as well as on a local level. This approach enables to develop tailor-made maps for different architectural elements and measurement conditions and to account at the same time for geological information and spatial relations between IRC measurements. (C) 2014 Elsevier B.V. All rights reserved.

69. **R. Borgoni, D. De Francesco, D. De Bartolo and N. Tzavidis**, **Hierarchical modeling of indoor radon concentration: how much do geology and building factors matter?** (**2014**), Journal/Journal of Environmental Radioactivity, 138, 227-237.

Radon is a natural gas known to be the main contributor to natural background radiation exposure and only second to smoking as major leading cause of lung cancer. The main concern is in indoor environments where the gas tends to accumulate and can reach high concentrations. The primary contributor of this gas into the building is from the soil although architectonic characteristics, such as building materials, can largely affect concentration values. Understanding the factors affecting the concentration in dwellings and workplaces is important both in prevention, when the construction of a new building is being planned, and in mitigation when the amount of Radon detected inside a building is too high. In this paper we investigate how several factors, such as geologic typologies of the soil and a range of building characteristics, impact on indoor concentration focusing, in particular, on how concentration changes as a function of the floor level. Adopting a mixed effects model to account for the hierarchical nature of the data, we also quantify the extent to which such measurable factors manage to explain the variability of indoor radon concentration. (C) 2014 Elsevier Ltd. All rights reserved.

b.   Intrusion de vapeurs (sites et sols pollues)

70. **A. Moradi, M. Tootkaboni and K. G. Pennell**, **A variance decomposition approach to uncertainty quantification and sensitivity analysis of the Johnson and Ettinger model** (**2015**), Journal/Journal of the Air & Waste Management Association, 65, 154-164.

The Johnson and Ettinger (J&E) model is the most widely used vapor intrusion model in the United States. It is routinely used as part of hazardous waste site assessments to evaluate the potential for vapor intrusion exposure risks. This study incorporates mathematical approaches that allow sensitivity and uncertainty of the J&E model to be evaluated. In addition to performing Monte Carlo simulations to examine the uncertainty in the J&E model output, a powerful global sensitivity analysis technique based on Sobol indices is used to evaluate J&E model sensitivity to variations in the input parameters. The results suggest that the J&E model is most sensitive to the building air exchange rate, regardless of soil type and source depth. Building air exchange rate is not routinely measured during vapor intrusion investigations, but clearly improved estimates and/or measurements of the air exchange rate would lead to improved model predictions. It is also found that the J&E model is more

sensitive to effective diffusivity than to effective permeability. Field measurements of effective diffusivity are not commonly collected during vapor intrusion investigations; however, consideration of this parameter warrants additional attention. Finally, the effects of input uncertainties on model predictions for different scenarios (e.g., sandy soil as compared to clayey soil, and "shallow" sources as compared to "deep" sources) are evaluated. Our results not only identify the range of variability to be expected depending on the scenario at hand, but also mark the important cases where special care is needed when estimating the input parameters to which the J&E model is most sensitive.

71. **I. Verginelli and R. Baciocchi**, **Vapor Intrusion Screening Model for the Evaluation of Risk-Based Vertical Exclusion Distances at Petroleum Contaminated Sites** (**2014**), Journal/Environmental Science & Technology, 48, 13263-13272.

The key role of biodegradation in attenuating the migration of petroleum hydrocarbon vapors into the indoor environments has been deeply investigated in the last decades. Very recently, empirical screening levels for the separation distance from the source, above which the potential for vapor intrusion can be considered negligible, were defined. In this paper, an analytical solution that allows one to predict risk-based vertical screening distances for hydrocarbons compounds is presented. The proposed solution relies on a 1-D vapor intrusion model that incorporates a piecewise first order aerobic biodegradation limited by oxygen availability and accounts also for the effect of the building footprint. The model predictions are shown to be consistent with the results obtained using a 3-D numerical model and with the empirical screening criteria defined by U.S.EPA and CRC care. However, the different simulations carried out show that in some specific cases (e.g., large building footprint, high methane concentration, and low attenuation in the capillary fringe), the respect of these empirical screening criteria could be insufficient to guarantee soil-gas concentrations below acceptable risk based levels.

c.   Autres (particules, QAI, Confort,…)

72. **J. Taylor, A. Mavrogianni, M. Davies, P. Das, C. Shrubsole, P. Biddulph and E. Oikonomou**, **Understanding and mitigating overheating and indoor PM2.5 risks using coupled temperature and indoor air quality models** (**2015**), Journal/Building Services Engineering Research & Technology, 36, 275-289.

Indoor temperature and air quality in dwellings are closely coupled. Differences between the indoor temperature and the temperature outside and in adjoining zones can influence airflow due to the stack effect, whilst changes in ventilation can cause changes in indoor pollution and temperature. This paper demonstrates the relationship between an indoor air pollutant, PM2.5, and temperature in UK domestic building archetypes using the dynamic thermal and contaminant modelling capabilities of EnergyPlus 8.0 under various UK Climate Projections 2009 (UKCP09) scenarios (current, current hot', 2050 High Emissions and 2050 High Emissions hot'), with both internal and external PM2.5 sources. Results indicate that flats have 0.7-0.8 times as much outdoor PM2.5 infiltrating indoors compared to detached dwellings, but 1.8-2.8 times more PM2.5 from indoor sources. During hot periods, temperature-dependent window opening increases exposure to outdoor PM2.5, meaning that as temperatures rises, dwelling occupants will become exposed to relatively higher levels of outdoor PM2.5 and lower levels of indoor PM2.5 due to the need to increase dwelling ventilation. The practical implications for government and designers and possible policy implications of this research are discussed.Practical applications: This paper demonstrates how an increase in summertime ventilation is necessary in UK homes to reduce overheating risks due to climate change and energy-efficient building retrofits. This, in turn, will lead to a change in the profile of indoor air pollution exposure, with greater exposure to pollution from

outdoor sources and reduced exposure to pollution from indoor sources. Roof insulation and trickle vents reduce overheating risk, whilst increased use of mechanical ventilation heat recovery systems in the UK is encouraged, as it offers the co-benefits of cooling through increased ventilation, energy recovery and the potential to reduce indoor pollution levels.

II.8 Air extérieur – Air intérieur

Rubrique N°15

73. **H. Krasnov, I. Katra, V. Novack, A. Vodonos and M. D. Friger**, **Increased indoor PM concentrations controlled by atmospheric dust events and urban factors** (**2015**), Journal/Building and Environment, 87, 169-176.

Dust storms are a common phenomenon, with significant impact on air pollution. Quantitative information on the influence of dust storms on particulate matter (PM) in the indoor environment is still lacking. Real-time PM10 and PM2.5 levels were measured simultaneously in outdoor and indoor air during dust events. A two-step multivariate analysis revealed factors controlling the PM levels. The results showed that during dust events average outdoor concentrations for PM10 and PM2.5 may reach 551 mu g m(-3) and 299 mu g m(-3), respectively. Indoor PM10 and PM2.5 levels may reach concentrations of 517 mu g m(-3) and 282 mu g m(-3), respectively. The analysis revealed a significant contribution of dust events to the indoor PM levels. The decreased in PM2.5/PM10 ratio in both environments during dust storms, indicating on 82% infiltration of the PM2.5 fraction into houses. The results serve to improve our understanding of dust storm, which may have implications for air quality and health issues. (C) 2015 Elsevier Ltd. All rights reserved.

74. **J. Taylor, C. Shrubsole, M. Davies, P. Biddulph, P. Das, I. Hamilton, S. Vardoulakis, A. Mavrogianni, B. Jones and E. Oikonomou**, **The modifying effect of the building envelope on population exposure to PM2.5 from outdoor sources** (**2014**), Journal/Indoor Air, 24, 639-651.

A number of studies have estimated population exposure to PM2.5 by examining modeled or measured outdoor PM2.5 levels. However, few have taken into account the mediating effects of building characteristics on the ingress of PM2.5 from outdoor sources and its impact on population exposure in the indoor domestic environment. This study describes how building simulation can be used to determine the indoor concentration of outdoor-sourced pollution for different housing typologies and how the results can be mapped using building stock models and Geographical Information Systems software to demonstrate the modifying effect of dwellings on occupant exposure to PM2.5 across London. Building archetypes broadly representative of those in the Greater London Authority were simulated for pollution infiltration using EnergyPlus. In addition, the influence of occupant behavior on indoor levels of PM2.5 from outdoor sources was examined using a temperature-dependent window-opening scenario. Results demonstrate a range of I/O ratios of PM2.5, with detached and semi-detached dwellings most vulnerable to high levels of infiltration. When the results are mapped, central London shows lower I/O ratios of PM2.5 compared with outer London, an apparent inversion of exposure most likely caused by the prevalence of flats rather than detached or semi-detached properties.

III. RISQUE ET IMPACT SUR LA SANTE

III.1   Toxicologie

Rubrique N°16

75. **P. T. J. Scheepers, M. van Ballegooij-Gevers and H. Jans**, **Biological monitoring involving children exposed to mercury from a barometer in a private residence** (**2014**), Journal/Toxicology Letters, 231, 365-373.

A small spill of approximately 3mL of mercury from a broken barometer in a residential setting resulted in blood values of 32 mu g/L in a boy of 9 months and 26 mu g/L in a girl of 2.5 years in samples collected within 6h after the start of the incident. A nanny who attempted to remove the spill had a blood mercury value of 20 mu g/L at the same time point. These elevated blood values were attributed to inhalation rather than dermal uptake or ingestion. Exposure was aggravated by the use of a vacuum cleaner in an early attempt to remove the spil land incomplete decontamination of involved persons, leading to a continuation of exposure. Over a period of three months general cleaning was followed by targeted cleaning of hot spots until the indoor air mercury levels reached a median value of 0.090 mu g/m(3) with a range of 0.032-0.140 mu g/m(3). Meanwhile the family was staying in a shelter home. Human biological monitoring (HBM) was motivated by the complex exposure situation and the involvement of young children. Initially high blood values triggered alertness for clinical signs of intoxication, that(as it turned out) were not observed in any of the exposed individuals. Despite continued exposure from hair and clothes, within six weeks after the incident, blood levels returned to a background level normally seen in children. HBM contributed to reassurance of the parents of the young children that quick elimination of the mercury did not require medical treatment. (C) 2014 Elsevier Ireland Ltd. All rights reserved.

III.2   Expologie

Rubrique N° 17

76. **C. Isaxon, A. Gudmundsson, E. Z. Nordin, L. Lonnblad, A. Dahl, G. Wieslander, M. Bohgard and A. Wierzbicka**, **Contribution of indoor-generated particles to residential exposure** (**2015**), Journal/Atmospheric Environment, 106, 458-466.

The majority of airborne particles in residences, when expressed as number concentrations, are generated by the residents themselves, through combustion/thermal related activities. These particles have a considerably smaller diameter than 2.5 mu m and, due to the combination of their small size, chemical composition (e.g. soot) and intermittently very high concentrations, should be regarded as having potential to cause adverse health effects. In this study, time resolved airborne particle measurements were conducted for seven consecutive days in 22 randomly selected homes in the urban area of Lund in southern Sweden. The main purpose of the study was to analyze the influence of human activities on the concentration of particles in indoor air. Focus was on number concentrations of particles with diameters <300 nm generated by indoor activities, and how these contribute to the integrated daily residential exposure. Correlations between these particles and soot mass concentration in total dust were also investigated. It was found that candle burning and activities related to cooking (using a frying pan, oven, toaster, and their combinations) were the major particle sources. The frequency of occurrence of a given concentration indoors and outdoors was compared for ultrafine particles. Indoor data was sorted into non-occupancy and occupancy time, and the occupancy time was further divided into non-activity and activity influenced time. It was found that high levels (above 10(4) cm(-3)) indoors mainly occur during active periods of occupancy, while the concentration during non-activity influenced

time differs very little from non-occupancy time. Total integrated daily residential exposure of ultrafine particles was calculated for 22 homes, the contribution from known activities was 66%, from unknown activities 20%, and from background/non-activity 14%. The collected data also allowed for estimates of particle source strengths for specific activities, and for some activities it was possible to estimate correlations between the number concentration of ultrafine particles and the mass concentration of soot in total dust in 10 homes. Particle source strengths (for 7 specific activities) ranged from 1.6.10(12) to 4.5.10(12) min(-1). The correlation between ultrafine particles and mass concentration of soot in total dust varied between 0.37 and 0.85, with an average of 0.56 (Pearson correlation coefficient). This study clearly shows that due to the importance of indoor sources, residential exposure to ultrafine particles cannot be characterized by ambient measurements alone. (C) 2014 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/3.0/).

77. **T. Hussein, A. Wierzbicka, J. Londahl, M. Lazaridis and O. Hanninen**, **Indoor aerosol modeling for assessment of exposure and respiratory tract deposited dose** (**2015**), Journal/Atmospheric Environment, 106, 402-411.

Air pollution is one of the major environmental problems that influence people's health. Exposure to harmful particulate matter (PM) occurs both outdoors and indoors, but while people spend most of their time indoors, the indoor exposures tend to dominate. Moreover, higher PM concentrations due to indoor sources and tightness of indoor environments may substantially add to the outdoor originating exposures. Empirical and real-time assessment of human exposure is often impossible; therefore, indoor aerosol modeling (IAM) can be used as a superior method in exposure and health effects studies. This paper presents a simple approach in combining available aerosol-based modeling techniques to evaluate the real-time exposure and respiratory tract deposited dose based on particle size. Our simple approach consists of outdoor aerosol data base, LAM simulations, time-activity pattern data-base, physical -chemical properties of inhaled aerosols, and semi-empirical deposition fraction of aerosols in the respiratory tract. These modeling techniques allow the characterization of regional deposited dose in any metric: particle mass, particle number, and surface area. The first part of this presentation reviews recent advances in simple mass-balance based modeling methods that are needed in analyzing the health relevance of indoor exposures. The second part illustrates the use of IAM in the calculations of exposure and deposited dose. Contrary to previous methods, the approach presented is a real-time approach and it goes beyond the exposure assessment to provide the required information for the health risk assessment, which is the respiratory tract deposited dose. This simplified approach is foreseen to support epidemiological studies focusing on exposures originating from both indoor and outdoor sources. (C) 2014 Elsevier Ltd. All rights reserved.

78. **K. Hoffman, S. Garantziotis, L. S. Birnbaum and H. M. Stapleton**, **Monitoring Indoor Exposure to Organophosphate Flame Retardants: Hand Wipes and House Dust** (**2015**), Journal/Environmental Health Perspectives, 123, 160-165.

BACKGROUND: Organophosphate flame retardants (PFRs) are becoming popular replacements for the phased-out polybrominated diphenyl ether (PBDE) mixtures, and they are now commonly detected in indoor environments. However, little is known about human exposure to PFRs because they cannot be easily measured in blood or serum. OBJECTIVES: To investigate relationships between the home environment and internal exposure, we assessed associations between two PFRs, tris(1,3-dichloropropyl) phosphate (TDCIPP) and triphenyl phosphate (TPHP), in paired hand wipe and dust samples and concentrations of their metabolites in urine samples (n = 53). We also assessed short-term variation in urinary metabolite concentrations (n = 11 participants; n = 49 samples).

METHODS: Adult volunteers in North Carolina, USA, completed questionnaires and provided urine, hand wipe, and household dust samples. PFRs and PBDEs were measured in hand wipes and dust, and bis(1,3-dichloropropyl) phosphate (BDCIPP) and diphenyl phosphate (DPHP), metabolites of TDCIPP and TPHP, were measured in urine. RESULTS: TDCIPP and TPHP were detected frequently in hand wipes and dust (> 86.8%), with geometric mean concentrations exceeding those of PBDEs. Unlike PBDEs, dust TDCIPP and TPHP levels were not associated with hand wipes. However, hand wipe levels were associated with urinary metabolites. Participants with the highest hand wipe TPHP mass, for instance, had DPHP levels 2.42 times those of participants with the lowest levels (95% CI: 1.23, 4.77). Women had higher levels of DPHP, but not BDCIPP. BDCIPP and DPHP concentrations were moderately to strongly reliable over 5 consecutive days (intra-class correlation coefficients of 0.81 and 0.51, respectively). CONCLUSIONS: PFR exposures are widespread, and hand-to-mouth contact or dermal absorption may be important pathways of exposure.

79. **A. Wierzbicka, M. Bohgard, J. H. Pagels, A. Dahl, J. Londahl, T. Hussein, E. Swietlicki and A. Gudmundsson**, **Quantification of differences between occupancy and total monitoring periods for better assessment of exposure to particles in indoor environments** (**2015**), Journal/Atmospheric Environment, 106, 419-428.

For the assessment of personal exposure, information about the concentration of pollutants when people are in given indoor environments (occupancy time) are of prime importance. However this kind of data frequently is not reported. The aim of this study was to assess differences in particle characteristics between occupancy time and the total monitoring period, with the latter being the most frequently used averaging time in the published data. Seven indoor environments were selected in Sweden and Finland: an apartment, two houses, two schools, a supermarket, and a restaurant. They were assessed for particle number and mass concentrations and number size distributions. The measurements using a Scanning Mobility Particle Sizer and two photometers were conducted for seven consecutive days during winter in each location. Particle concentrations in residences and schools were, as expected, the highest during occupancy time. In the apartment average and median PM2.5 mass concentrations during the occupancy time were 29% and 17% higher, respectively compared to total monitoring period. In both schools, the average and medium values of the PM2.5 mass concentrations were on average higher during teaching hours compared to the total monitoring period by 16% and 32%, respectively. When it comes to particle number concentrations (PNC), in the apartment during occupancy, the average and median values were 33% and 58% higher, respectively than during the total monitoring period. In both houses and schools the average and median PNC were similar for the occupancy and total monitoring periods. General conclusions on the basis of measurements in the limited number of indoor environments cannot be drawn. However the results confirm a strong dependence on type and frequency of indoor activities that generate particles and site specificity. The results also indicate that the exclusion of data series during non-occupancy periods can improve the estimates of particle concentrations and characteristics suitable for exposure assessment, which is crucial for estimating health effects in epidemiological and toxicological studies. (C) 2014 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/3.0/).

80. **T. Zhang, X. J. Chen, D. Wang, R. D. Li, Y. F. Ma, W. W. Mo, H. W. Sun and K. Kannan**, **Perchlorate in Indoor Dust and Human Urine in China: Contribution of Indoor Dust to Total Daily Intake** (**2015**), Journal/Environmental Science & Technology, 49, 2443-2450.

Perchlorate is used in fireworks and China is the largest fireworks producer and consumer in the world. Information regarding human exposure to perchlorate is scarce in China, and exposure via indoor dust ingestion (EDIindoor dust) has rarely been evaluated. In this study, perchlorate was found in indoor dust (detection rate: 100%, median: 47.4 mu g/g), human urine (99%, 26.2 ng/mL), drinking water (100%, 3.99 ng/mL), and dairy milk (100%, 12.3 ng/mL) collected from cities that have fireworks manufacturing areas (Yueyang and Nanchang) and in cities that do not have fireworks manufacturing industries (Tianjin, Shijiazhuang, Yuxi and Guilin) in China. In comparison with perchlorate levels reported for other countries, perchlorate levels in urine samples from fireworks sites and nonfireworks sites in China were higher. Median indoor dust perchlorate concentrations were positively correlated (r = 0.964, p < 0.001) with outdoor dust perchlorate levels reported previously. The total daily intake (EDItoal) of perchlorate, estimated based on urinary levels, ranged from 0.090 to 27.72 mu g/kg body weight (bw)/day for all studied participants; the percentage of donors who had EDItotal exceeding the reference dose (RfD) recommended by the United States Environmental Protection Agency (US EPA) was 79%, 48%, and 25% for toddlers (median: 1.829 mu g/kg bw/day), adults (0.669 mu g/kg bw/day), and children (median: 0.373 mu g/kg bw/day), respectively. Toddlers (0.258 mu g/kg bw/day) had the highest median EDIindoor dust, which was 2 to 5 times greater than the EDIindoor dust calculated for other age groups (the range of median values: 0.044 to 0.127 mu g/kg bw/day). Contribution of indoor dust to EDItotal was 26%, 28%, and 7% for toddlers, children, and adults, respectively. Indoor dust contributed higher percentage to EDItotal than that by dairy milk (0.55%).

81. → **Y. J. Wan, Q. Wu, K. O. Abualnaja, A. G. Asimakopoulos, A. Covaci, B. Gevao, B. Johnson-Restrepo, T. A. Kumosani, G. Malarvannan, H. B. Moon, H. Nakata, R. K. Sinha, T. B. Minh and K. Kannan**, **Occurrence of perchlorate in indoor dust from the United States and eleven other countries: Implications for human exposure** (**2015**), Journal/Environment International, 75, 166-171.

Perchlorate is a widespread environmental contaminant and potent thyroid hormone disrupting compound. Despite this, very little is known with regard to the occurrence of this compound in indoor dust and the exposure of humans to perchlorate through dust ingestion. In this study, 366 indoor dust samples were collected from 12 countries, the USA, Colombia, Greece, Romania, Japan, Korea, Pakistan, Kuwait, Saudi Arabia, India, Vietnam, and China, during 2010-2014. Dust samples were extracted by 1% (v/v) methylamine in water. Analyte separation was achieved by an ion exchange (AS-21) column and analysis was performed by high performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS). The overall concentrations of perchlorate in dust were in the range of 0.02-104 mu g/g (geometric mean: 0.41 mu g/g). The indoor dust samples from China contained the highest concentrations (geometric mean: 5.38 mu g/g). No remarkable differences in perchlorate concentrations in dust were found among various microenvironments (i.e., car, home, office, and laboratory). The estimated median daily intake (EDI) of perchlorate for toddlers through dust ingestion in the USA, Colombia, Greece, Romania, Japan, Korea, Pakistan, Kuwait, Saudi Arabia, India, Vietnam, and China was 1.89, 0.37, 1.71, 0.74, 4.90, 720, 0.60, 0.80, 1.55, 0.70, 2.15, and 21.3 ng/kg body weight (bw)/day, respectively. Although high concentrations of perchlorate were measured in some dust samples, the contribution of dust to total perchlorate intake was <5% of the total perchlorate intake in humans. This is the first

multinational survey on the occurrence of perchlorate in indoor dust. (C) 2014 Elsevier Ltd. All rights reserved.

82. **S. Mizouchi, M. Ichiba, H. Takigami, N. Kajiwara, T. Takamuku, T. Miyajima, H. Kodama, T. Someya and D. Ueno**, **Exposure assessment of organophosphorus and organobromine flame retardants via indoor dust from elementary schools and domestic houses** (**2015**), Journal/Chemosphere, 123, 17-25.

To assess the exposure of flame retardants (FRs) for school-children, organophosphorus flame retardants and plasticizers (PFRs) and organobromine flame retardants (BFRs) were determined in the indoor dust samples collected from elementary schools and domestic houses in Japan in 2009 and 2010. PFRs were detected in all the dust samples analyzed and the highest concentration of total PFRs was thousand-fold higher than that of BFRs. Among the PFRs, tris(butoxyethyl)phosphate (TBOEP) showed the highest concentration with a median (med.) of 270000 ng g(-1) dry weight (3700-5500000 ng g(-1) dry weight), followed by tris(methylphenyl)phosphate (TMPPs) > triphenyl phosphate (TPHP) = tris(1,3-dichloro-2propyl)phosphate (TDCIPP) = tris(2-chloroisopropyl)phosphate (TCIPP) = tris(2chloroethyl)phosphate (TCEP) > ethylhexyl diphenyl phosphate (EHDPP). Significantly higher concentrations of TBOEP, tri-n-butyl phosphate (TNBP), TPHP, TMPPs, and total-PERs were found in dust samples from elementary schools than from domestic houses. It might be due to that higher concentrations of TBOEP (as leveling agent) were detected from the floor polisher/wax products collected in those elementary schools. On the other hand, significantly higher concentrations of TCEP, TCIPPs, and total chloroalkyl-PERs were found in domestic houses than in elementary schools. Exposure assessments of PFRs via indoor dust from elementary schools and domestic houses were conducted by calculating the hazard quotient (HQ). Among PFRs, HQs for TBOEP exceeded 1 (higher than reference dose: RfD) and its highest value was 1.9. To reduce the intake of TBOEP by school-children, it is recommended that the use of floor polisher/wax containing TBOEP be reduced in schools. (C) 2014 Elsevier Ltd. All rights reserved.

83. **R. E. Dodson, D. E. Camann, R. Morello-Frosch, J. G. Brody and R. A. Rudel**, **Semivolatile Organic Compounds in Homes: Strategies for Efficient and Systematic Exposure Measurement Based on Empirical and Theoretical Factors** (**2015**), Journal/Environmental Science & Technology, 49, 113-122.

Residential exposure can dominate total exposure for commercial chemicals of health concern; however, despite the importance of consumer exposures, methods for estimating household exposures remain limited. We collected house dust and indoor air samples in 49 California homes and analyzed for 76 semivolatile organic compounds (SVOCs)-phthalates, polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides. Sixty chemicals were detected in either dust or air and here we report 58 SVOCs detected in dust for the first time. In dust, phthalates (bis(2-ethylhexyl) phthalate, benzyl butyl phthalate, di-n-butyl phthalate) and flame retardants (PBDE 99, PBDE 47) were detected at the highest concentrations relative to other chemicals at the 95th percentile, while phthalates were highest at the median. Because SVOCs are found in both gas and condensed phases and redistribute from their original source over time, partitioning models can clarify their fate indoors. We use empirical data to validate air-dust partitioning models and use these results, combined with experience in SVOC exposure assessment, to recommend residential exposure measurement strategies. We can predict dust concentrations reasonably well from measured air concentrations (R-2 = 0.80). Partitioning models and knowledge of chemical K-oa elucidate exposure pathways and suggest priorities for chemical regulation. These findings also inform study design by allowing researchers to select sampling approaches optimized for their chemicals of interest

and study goals. While surface wipes are commonly used in epidemiology studies because of ease of implementation, passive air sampling may be more standardized between homes and also relatively simple to deploy. Validation of passive air sampling methods for SVOCs is a priority.

84. **C. Brokamp, M. B. Rao, Z. H. Fan and P. H. Ryan, Does the elemental composition of indoor and outdoor PM2.5 accurately represent the elemental composition of personal PM2.5?** (**2015**), Journal/Atmospheric Environment, 101, 226-234.

The complex mixture of chemical and elemental constituents that comprise particulate matter (PM) is hypothesized to be, in part, responsible for its toxicity. Epidemiologic studies have identified specific components and sources of PM2.5 associated with adverse health outcomes, but the majority of these studies use the mass concentration of elements in outdoor PM2.5 at central monitoring sites as a surrogate for personal exposure. Personal exposure to PM2.5 and its elemental composition, however, may vary from stationary outdoor measurements. Here, we use concurrent indoor, outdoor, and personal sampling of PM2.5 and its elemental constituents along with personal and home characteristics, collected as a part of the Relationships of Indoor, Outdoor, and Personal Air (RIOPA) study to characterize the differences in PM2.5 among indoor, outdoor, and personal air samples. We found that personal exposure to PM2.5 and most elements were significantly correlated with, though frequently exceeded, both indoor and outdoor measurements. Principal component scores were used to determine that the mixture of elemental components in PM2.5 varies significantly across indoor, outdoor, and personal sample types. Using model-based clustering, we identified 7 clusters of RIOPA participants whose personal PM2.5 samples had similar patterns of elemental composition. Using this approach, two subsets of RIOPA participants were identified whose personal exposure to PM2.5 and elemental concentrations were significantly increased compared to both their indoor and outdoor levels. Collectively, our results suggest that the elemental composition of PM2.5 obtained at central monitoring stations do not accurately represent the overall elemental composition of personal PM2.5 exposure.

85. **X. M. Wu, D. H. Bennett, R. E. Moran, A. Sjodin, R. S. Jones, D. J. Tancredi, N. S. Tulve, M. S. Clifton, M. Colon, W. Weathers and I. Hertz-Picciotto, Polybrominated diphenyl ether serum concentrations in a Californian population of children, their parents, and older adults: an exposure assessment study** (**2015**), Journal/Environmental Health, 14, 11.

Background: Polybrominated diphenyl ethers (PBDEs) are used as flame retardants in many household items. Given concerns over their potential adverse health effects, we identified predictors and evaluated temporal changes of PBDE serum concentrations. Methods: PBDE serum concentrations were measured in young children (2-8 years old; N = 67), parents of young children (<55 years old; N = 90), and older adults (= 55 years old; N = 59) in California, with concurrent floor wipe samples collected in participants' homes in 2008-2009. We also measured serum concentrations one year later in a subset of children (N = 19) and parents (N = 42). Results: PBDE serum concentrations in children were significantly higher than in adults. Floor wipe concentration is a significant predictor of serum BDE-47, 99, 100 and 154. Positive associations were observed between the intake frequency of canned meat and serum concentrations of BDE-47, 99 and 154, between canned meat entrees and BDE-154 and 209, as well as between tuna and white fish and BDE-153. The model with the floor wipe concentration and food intake frequencies explained up to 40% of the mean square prediction error of some congeners. Lower home values and renting (vs. owning) a home were associated with higher serum concentrations of BDE-47, 99 and 100. Serum concentrations measured one year apart were strongly correlated as expected (r = 0.70-0.97)

with a slight decreasing trend. Conclusions: Floor wipe concentration, food intake frequency, and housing characteristics can explain 12-40% of the prediction error of PBDE serum concentrations. Decreasing temporal trends should be considered when characterizing long-term exposure.

86. **S. S. Andra, P. Charisiadis, S. Karakitsios, D. A. Sarigiannis and K. C. Makris**, **Passive exposures of children to volatile trihalomethanes during domestic cleaning activities of their parents** (**2015**), Journal/Environmental Research, 136, 187-195.

Domestic cleaning has been proposed as a determinant of trihalomethanes (THMs) exposure in adult females. We hypothesized that parental housekeeping activities could influence children's passive exposures to THMs from their mere physical presence during domestic cleaning. In a recent cross-sectional study (n=382) in Cyprus [41 children (< 18y) and 341 adults (>= 18y)], we identified 29 children who met the study's inclusion criteria. Linear regression models were applied to understand the association between children sociodemographic variables, their individual practices influencing ingestion and noningestion exposures to Sigma THMs, and their urinary THMs levels. Among the children-specific variables, age alone showed a statistically significant inverse association with their creatinine-adjusted urinary Sigma THMs (r(s)= -0.59, p < 0.001). A positive correlation was observed between urinary Sigma THMs (ng g(-1)) of children and matched-mothers (r(s)=0.52, p=0.014), but this was not the case for their matched-fathers (r(s)=0.39, p=0.112). Time spent daily by the matched-mothers for domestic mopping, toilet and other cleaning activities using chlorine-based cleaning products was associated with their children's urinary THMs levels (r(s)=0.56, p=0.007). This trend was not observed between children and their matched-fathers urinary Sigma THMs levels, because of minimum amount of time spent by the latter in performing domestic cleaning. The proportion of variance of creatinine-unadjusted and adjusted urinary Sigma THMs levels in children that was explained by the matched-mothers covariates was 76% and 74% (p < 0.001), respectively. A physiologically-based pharmacokinetic model adequately predicted urinary chloroform excretion estimates, being consistent with the corresponding measured levels. Our findings highlighted the influence of mothers' domestic cleaning activities towards enhancing passive THMs exposures of their children. The duration of such activities could be further tested as a valid indicator of children's THMs body burden. (C) 2014 Elsevier Inc. All rights reserved.

87. **X. M. Wu, D. H. Bennett, A. M. Calafat, K. Kato, M. Strynar, E. Andersen, R. E. Moran, D. J. Tancredi, N. S. Tulve and I. Hertz-Picciotto**, **Serum concentrations of perfluorinated compounds (PFC) among selected populations of children and Adults in California** (**2015**), Journal/Environmental Research, 136, 264-273.

Perfluorinated compounds (PFCs) have been widely used in industrial applications and consumer products. Their persistent nature and potential health impacts are of concern. Given the high cost of collecting serum samples, this study is to understand whether we can quantify PFC serum concentrations using factors extracted from questionnaire responses and indirect measurements, and whether a single serum measurement can be used to classify an individual's exposure over a one-year period. The study population included three demographic groups: young children (2-8 years old) (N=67), parents of young children (< 55 years old) (N=90), and older adults (> 55 years old) (N=59). PFC serum concentrations, house dust concentrations, and questionnaires were collected. The geometric mean of perfluorooctane sulfonic acid (PFOS) was highest for the older adults. In contrast, the geometric mean of perfluorooctanoic acid (PFOA) was highest for children. Serum concentrations of the parent and the child from the same family were moderately correlated (Spearman correlation (r)=0.26-0.79, p <0.05), indicating common sources within a family. For adults, age, having occupational exposure or having used fire extinguisher, frequencies

of consuming butter/margarine, pork, canned meat entres, tuna and white fish, freshwater fish, and whether they ate microwave popcorn were significantly positively associated with serum concentrations of individual PFCs. For children, residential dust concentrations, frequency of wearing waterproof clothes, frequency of having canned fish, hotdogs, chicken nuggets, French fries, and chips, and whether they ate microwave popcorn were significant positive predictors of individual PFC serum concentrations. In addition, the serum concentrations collected in a subset of young children (N=20) and the parents (N=42) one year later were strongly correlated (r=0.68-0.98, p <0.001) with the levels measured at the first visits, but showed a decreasing trend. Children had moderate correlation (r=0.43) between serum and dust concentrations. of PFOS, indicating indoor sources contribute to exposure. In conclusion, besides food intake, occupational exposure, consumer product use, and exposure to residential dust contribute to PFC exposure. The downward temporal trend of serum concentrations reflects the reduction of PFCs use in recent years while the year-to-year correlation indicates that a single serum measurement could be an estimate of exposure relative to the population for a one-year period in epidemiology studies.

88. **E. Cequier, R. M. Marce, G. Becher and C. Thomsen**, **Comparing human exposure to emerging and legacy flame retardants from the indoor environment and diet with concentrations measured in serum** (**2015**), Journal/Environment International, 74, 54-59.

This study investigates associations between serum concentrations of emerging and legacy halogenated flame retardants (HFRs) in 46 Norwegian women and measured indoor air and dust concentrations of the HFRs as well as detailed information on diet and household factors. Hexabromobenzene (median 0.03 ng/g lipid) and Dechlorane 602 (median 0.18 ng/g lipid) were detected in about 50% of the samples and Dechlorane Plus syn (median 0.45 ng/g lipid) and anti (median 0.85 ng/g lipid) in more than 78%. The most abundant polybrominated diphenyl ethers were 2,2',4,4',5,5'-hexabromodiphenyl ether (BDE-153; median 0.82 ng/g lipid) and 2,2',4,4'-tetrabromodiphenyl ether (BDE-47; median 0.49 ng/g lipid) detected in more than 70% of the samples. In the bivariate analysis, no consistent associations were observed between the biomonitoring data and measured concentrations in indoor air and dust On the other hand, consumption of specific food items (mainly lamb/mutton and margarine) correlated significantly with more than two HFR serum concentrations, while this was not the case for household factors (electronic appliances). Only the significant bivariate associations with diet were confirmed by multivariate linear regression analyses, which might indicate a higher contribution from food compared to the indoor environment to the variation of the body burden of these HFRs.

89. **R. E. Dodson, N. Van den Eede, A. Covaci, L. J. Perovich, J. G. Brody and R. A. Rudel**, **Urinary Biomonitoring of Phosphate Flame Retardants: Levels in California Adults and Recommendations for Future Studies** (**2014**), Journal/Environmental Science & Technology, 48, 13625-13633.

Phosphate flame retardants (PFRs) are abundant and found at the highest concentrations relative to other flame retardant chemicals in house dust; however, little is known about the biological levels of PFRs and their relationship with house dust concentrations. These relationships provide insight into major exposure pathways and potential health risks. We analyzed urine samples from 16 California residents in 2011 for 6 chlorinated and nonchlorinated dialkyl or diaryl phosphates (DAPs), the expected major metabolites of the most prominent PFRs, and qualitatively screened for 18 other metabolites predicted from in vitro studies. We detected all 6 DAPs within the range of previously reported levels, although very few comparisons are available. We found weakly positive nonsignificant correlations

between urine and dust concentrations and maxima urine corresponding to maxima dust for the pairs bis(1,3-dichloro-2-propyl) phosphate (BDCIPP)-tris(1,3-dichloro-isopropyl) phosphate (TDCIPP) and bis(2-chloroethyl) phosphate (BCEP)-tris(2-chloroethyl) phosphate (TCEP). Metabolite levels of PFRs were correlated for many PFR combinations, suggesting they commonly co-occur. As far as we know, this is the first study to measure these 6 DAP metabolites simultaneously and to detect other PFR metabolites in US urine samples. We recommend biomonitoring studies include these 6 DAPs as well as several additional compounds detected through qualitative screening and previous ADME studies. PFRs represent a class of poorly studied commercial chemicals with widespread exposure and raise concerns for health effects including carcinogenicity and neurotoxicity.

90. **A. Bradman, R. Castorina, F. Gaspar, M. Nishioka, M. Colon, W. Weathers, P. P. Egeghy, R. Maddalena, J. Williams, P. L. Jenkins and T. E. McKone**, **Flame retardant exposures in California early childhood education environments** (**2014**), Journal/Chemosphere, 116, 61-66.

Infants and young children spend as much as 50 h per week in child care and preschool. Although approximately 13 million children, or 65% of all U.S. children, spend some time each day in early childhood education (ECE) facilities, little information is available about environmental exposures in these environments. We measured flame retardants in air and dust collected from 40 California ECE facilities between May 2010 and May 2011. Low levels of six polybrominated diphenyl ether (PBDE) congeners and four non-PBDE flame retardants were present in air, including two constituents of Firemaster 550 and two tris phosphate compounds [tris (2-chloroethyl) phosphate (TCEP) and tris (1,3-dichloroisopropyl) phosphate (TDCIPP)]. Tris phosphate, Firemaster 550 and PBDE compounds were detected in 100% of the dust samples. BDE47, BDE99, and BDE209 comprised the majority of the PBDE mass measured in dust. The median concentrations of TCEP (319 ng g(-1)) and TDCIPP (2265 ng g(-1)) were similar to or higher than any PBDE congener. Levels of TCEP and TDCIPP in dust were significantly higher in facilities with napping equipment made out of foam (Mann Whitney p-values < 0.05). Child BDE99 dose estimates exceeded the RID in one facility for children < 3 years old. In 51% of facilities, TDCIPP dose estimates for children < 6 years old exceeded age-specific "No Significant Risk Levels (NSRLs)" based on California Proposition 65 guidelines for carcinogens. Given the overriding interest in providing safe and healthy environments for young children, additional research is needed to identify strategies to reduce indoor sources of flame retardant chemicals. (C) 2014 Elsevier Ltd. All rights reserved.

91. **F. M. Gerster, N. B. Hopf, P. P. Wild and D. Vernez**, **Airborne Exposures to Monoethanolamine, Glycol Ethers, and Benzyl Alcohol During Professional Cleaning: A Pilot Study** (**2014**), Journal/Annals of Occupational Hygiene, 58, 846-859.

A growing body of epidemiologic evidence suggests an association between exposure to cleaning products and respiratory dysfunction. Due to the lack of quantitative assessments of respiratory exposures to airborne irritants and sensitizers among professional cleaners, the culpable substances have yet to be identified. Purpose: Focusing on previously identified irritants, our aims were to determine (i) airborne concentrations of monoethanolamine (MEA), glycol ethers, and benzyl alcohol (BA) during different cleaning tasks performed by professional cleaning workers and assess their determinants; and (ii) air concentrations of formaldehyde, a known indoor air contaminant. Methods: Personal air samples were collected in 12 cleaning companies, and analyzed by conventional methods. Results: Nearly all air concentrations [MEA (n = 68), glycol ethers (n = 79), BA (n = 15), and formaldehyde (n = 45)] were far below (< 1/10) of the corresponding Swiss occupational exposure limits (OEL), except for ethylene glycol mono-n-butyl ether (EGBE). For butoxypropanol and BA, no OELs exist. Although only detected once, EGBE air concentrations (n = 4) were high

(49.48-58.72 mg m(-3)), and close to the Swiss OEL (49 mg m(-3)). When substances were not noted as present in safety data sheets of cleaning products used but were measured, air concentrations showed no presence of MEA, while the glycol ethers were often present, and formaldehyde was universally detected. Exposure to MEA was affected by its amount used (P = 0.036), and spraying (P = 0.000) and exposure to butoxypropanol was affected by spraying (P = 0.007) and cross-ventilation (P = 0.000). Conclusions: Professional cleaners were found to be exposed to multiple airborne irritants at low concentrations, thus these substances should be considered in investigations of respiratory dysfunctions in the cleaning industry; especially in specialized cleaning tasks such as intensive floor cleaning.

III.3   Épidémiologie

Rubrique N°18

92. **J. Wang, G. Smedje, T. Nordquist and D. Norback**, **Personal and demographic factors and change of subjective indoor air quality reported by school children in relation to exposure at Swedish schools: A 2-year longitudinal study** (**2015**), Journal/Science of the Total Environment, 508, 288-296.

This paper studies changes in subjective indoor air quality (SIAQ) among school children and relates these data to repeated exposure measurements during a two-year follow-up period. Data on SIAQand demographic information were gathered by a questionnaire sent to 1476 primary and secondary school pupils in 39 randomly selected schools at baseline and after two years (follow-up). Exposure measurements were applied after questionnaire data were collected at baseline and follow-up in approximately 100 classrooms. The arithmetic mean values for baseline and follow-up were: for indoor air temperature 23.6 degrees C and 21.8 degrees C and for outdoor air flow rate 5.4 L/s and 7.9 L/s. Older children, those with atopy at baseline, and those in larger schools reported impaired SIAQ during follow-up. Installation of new ventilation systems, higher personal air flow rate and air exchange rate, and better illumination were associated with improved SIAQ, Higher CO2 levels were associated with impaired SIAQ, In conclusion, sufficient ventilation and illumination in classrooms are essential for the perception of good indoor air quality. (C) 2014 Elsevier B.V. All rights reserved.

93. **S. Rocchi, G. Reboux, V. Frossard, E. Scherer, B. Valot, A. Laboissiere, C. Zaros, M. Vacheyrou, F. Gillet, S. Roussel, C. Raherison, L. Millon and Team Elfe**, **Microbiological characterization of 3193 French dwellings of Elfe cohort children** (**2015**), Journal/Science of the Total Environment, 505, 1026-1035.

Although exposure to indoor microorganisms in early life has already been associated with respiratory illness or allergy protection, only a few studies have performed standardized samplings and specific microbial analysis. Moreover, most do not target the different groups of microorganisms involved in respiratory diseases (fungi, bacteria, dust mites). In our study, ten specific qPCR targets (6 fungal species, 1 family and 2 genera of bacteria, 1 house dust mite) were used to analyze the microorganism composition of electrostatic dust fall collector (EDC) from 3193 dwellings of the Elfe French cohort study. Multivariate analyses allowed us to show that the microbial composition of dwellings, assessed with simultaneous analysis of 10 microorganisms, can be characterized by four entities: three bacteria, house dust mite Dermatophagokies pteronyssinus, fungi Alternaria alternate, and five other molds. Some dwellings' intrinsic characteristics (occupational ratio, type of dwelling and presence of pets) clearly influence microorganism distribution, and six different profiles of dwellings, characterized by their composition in microorganisms, have been described across France.

The use of these clusters seems promising in the evaluation of allergic risk. Allergic respiratory diseases will develop in the near future in some children of the Elfe cohort and will indicate to what extent our approach can be predictive of respiratory disease. (C) 2014 Elsevier B.V. All rights reserved.

94. **A. J. White, S. L. Teitelbaum, S. D. Stellman, J. Beyea, S. E. Steck, I. Mordukhovich, K. M. McCarty, J. Ahn, P. Rossner, R. M. Santella and M. D. Gammon**, **Indoor air pollution exposure from use of indoor stoves and fireplaces in association with breast cancer: a case-control study** (**2014**), Journal/Environmental Health, 13, 108-108.

Background: Previous studies suggest that polycyclic aromatic hydrocarbons (PAHs) may adversely affect breast cancer risk. Indoor air pollution from use of indoor stoves and/or fireplaces is an important source of ambient PAH exposure. However, the association between indoor stove/fireplace use and breast cancer risk is unknown. We hypothesized that indoor stove/fireplace use in a Long Island, New York study population would be positively associated with breast cancer and differ by material burned, and the duration and timing of exposure. We also hypothesized that the association would vary by breast cancer subtype defined by p53 mutation status, and interact with glutathione S-transferases GSTM1, T1, A1 and P1 polymorphisms. Methods: Population-based, case-control resources (1,508 cases/1,556 controls) were used to conduct unconditional logistic regression to estimate adjusted odds ratios (OR) and 95% confidence intervals (CI). Results: Breast cancer risk was increased among women reporting ever burning synthetic logs (which may also contain wood) in their homes (OR = 1.42, 95% CI 1.11, 1.84), but not for ever burning wood alone (OR = 0.93, 95% CI 0.77, 1.12). For synthetic log use, longer duration >7 years, older age at exposure (>20 years; OR = 1.65, 95% CI 1.02, 2.67) and 2 or more variants in GSTM1, T1, A1 or P1 (OR = 1.71, 95% CI 1.09, 2.69) were associated with increased risk. Conclusions: Burning wood or synthetic logs are both indoor PAH exposure sources; however, positive associations were only observed for burning synthetic logs, which was stronger for longer exposures, adult exposures, and those with multiple GST variant genotypes. Therefore, our results should be interpreted with care and require replication.

95. **Y. Olsen, D. G. Karottki, D. M. Jensen, G. Beko, B. U. Kjeldsen, G. Clausen, L. G. Hersoug, G. J. Holst, A. Wierzbicka, T. Sigsgaard, A. Linneberg, P. Moller and S. Loft**, **Vascular and lung function related to ultrafine and fine particles exposure assessed by personal and indoor monitoring: a cross-sectional study** (**2014**), Journal/Environmental Health, 13, 112-112.

Background: Exposure to ambient air particulate matter (PM) has been linked to decline in pulmonary function and cardiovascular events possibly through inflammation. Little is known about individual exposure to ultrafine particles (UFP) inside and outside modern homes and associated health-related effects. Methods: Associations between vascular and lung function, inflammation markers and exposure in terms of particle number concentration (PNC; d = 10-300 nm) were studied in a cross-sectional design with personal and home indoor monitoring in the Western Copenhagen Area, Denmark. During 48-h, PNC and PM2.5 were monitored in living rooms of 60 homes with 81 non-smoking subjects (30-75 years old), 59 of whom carried personal monitors both when at home and away from home. We measured lung function in terms of the FEV1/FVC ratio, microvascular function (MVF) and pulse amplitude by digital artery tonometry, blood pressure and biomarkers of inflammation including C-reactive protein, and leukocyte counts with subdivision in neutrophils, eosinophils, monocytes, and lymphocytes in blood. Results: PNC from personal and stationary home monitoring showed weak correlation (r = 0.15, p = 0.24). Personal UFP exposure away from home was significantly inversely associated with MVF (1.3% decline per interquartile range,

95% confidence interval: 0.1-2.5%) and pulse amplitude and positively associated with leukocyte and neutrophil counts. The leukocyte and neutrophil counts were also positively and pulse amplitude negatively associated with total personal PNC. Indoor PNC and PM2.5 showed positive association with blood pressure and inverse association with eosinophil counts. Conclusions: The inverse association between personal exposure away from home and MVF is consistent with adverse health effects of UFP from sources outside the home and might be related to increased inflammation indicated by leukocyte counts, whereas UFP from sources in the home could have less effect.

96. **J. Sunyer, M. Esnaola, M. Alvarez-Pedrerol, J. Forns, I. Rivas, M. Lopez-Vicente, E. Suades-Gonzalez, M. Foraster, R. Garcia-Esteban, X. Basagana, M. Viana, M. Cirach, T. Moreno, A. Alastuey, N. Sebastian-Galles, M. Nieuwenhuijsen and X. Querol**, **Association between Traffic-Related Air Pollution in Schools and Cognitive Development in Primary School Children: A Prospective Cohort Study** (**2015**), Journal/Plos Medicine, 12, 24.

Background Air pollution is a suspected developmental neurotoxicant. Many schools are located in close proximity to busy roads, and traffic air pollution peaks when children are at school. We aimed to assess whether exposure of children in primary school to traffic-related air pollutants is associated with impaired cognitive development. Methods and Findings We conducted a prospective study of children (n = 2,715, aged 7 to 10 y) from 39 schools in Barcelona (Catalonia, Spain) exposed to high and low traffic-related air pollution, paired by school socioeconomic index; children were tested four times (i.e., to assess the 12-mo developmental trajectories) via computerized tests (n = 10,112). Chronic traffic air pollution (elemental carbon [EC], nitrogen dioxide [NO2], and ultrafine particle number [UFP; 10-700 nm]) was measured twice during 1-wk campaigns both in the courtyard (outdoor) and inside the classroom (indoor) simultaneously in each school pair. Cognitive development was assessed with the n-back and the attentional network tests, in particular, working memory (two-back detectability), superior working memory (three-back detectability), and inattentiveness (hit reaction time standard error). Linear mixed effects models were adjusted for age, sex, maternal education, socioeconomic status, and air pollution exposure at home. Children from highly polluted schools had a smaller growth in cognitive development than children from the paired lowly polluted schools, both in crude and adjusted models (e.g., 7.4% [95% CI 5.6%-8.8%] versus 11.5%[95% CI 8.9%-12.5%] improvement in working memory, p = 0.0024). Cogently, children attending schools with higher levels of EC, NO2, and UFP both indoors and outdoors experienced substantially smaller growth in all the cognitive measurements; for example, a change from the first to the fourth quartile in indoor EC reduced the gain in working memory by 13.0% (95% CI 4.2%-23.1%). Residual confounding for social class could not be discarded completely; however, the associations remained in stratified analyses (e.g., for type of school or high-/low-polluted area) and after additional adjustments (e.g., for commuting, educational quality, or smoking at home), contradicting a potential residual confounding explanation. Conclusions Children attending schools with higher traffic-related air pollution had a smaller improvement in cognitive development.

97. **S. Banerjee, Y. Resch, K. W. Chen, I. Swoboda, M. Focke-Tejkl, K. Blatt, N. Novak, M. Wickman, M. van Hage, R. Ferrara, A. Mari, A. Purohit, G. Pauli, E. N. Sibanda, P. Ndlovu, W. R. Thomas, V. Krzyzanek, S. Tacke, U. Malkus, P. Valent, R. Valenta and S. Vrtala**, **Der p 11 Is a Major Allergen for House Dust Mite-Allergic Patients Suffering from Atopic Dermatitis** (**2015**), Journal/Journal of Investigative Dermatology, 135, 102-109.

House dust mites (HDMs) belong to the most potent indoor allergen sources worldwide and are associated with allergic manifestations in the respiratory tract and the skin. Here we studied the importance of the high-molecular-weight group 11 allergen from Dermatophagoides pteronyssinus (Der p 11) in HDM allergy. Sequence analysis showed that Der p 11 has high homology to paramyosins from mites, ticks, and other invertebrates. A synthetic gene coding for Der p 11 was expressed in Escherichia coli and rDer p 11 purified to homogeneity as folded, alpha-helical protein as determined by circular dichroisnn spectroscopy. Using antibodies raised against rDer p 11 and immunogold electron microscopy, the allergen was localized in the muscle beneath the skin of mite bodies but not in feces. IgE reactivity of rDer p 11 was tested with sera from HDM-allergic patients from Europe and Africa in radioallergosorbent test based dot-blot assays. Interestingly, we found that Der p 11 is a major allergen for patients suffering from atopic dermatitis (AD), whereas it is only a minor allergen for patients suffering from respiratory forms of HDM allergy. Thus, rDer p 11 might be a useful serological marker allergen for the identification of a subgroup of HDM-allergic patients suffering from HDM-associated AD.

98. **M. Foraster, N. Kunzli, I. Aguilera, M. Rivera, D. Agis, J. Vila, L. Bouso, A. Deltell, J. Marrugat, R. Ramos, J. Sunyer, R. Elosua and X. Basagna**, **High Blood Pressure and Long-Term Exposure to Indoor Noise and Air Pollution from Road Traffic** (**2014**), Journal/Environmental Health Perspectives, 122, 1193-1200.

Background: Traffic noise has been associated with prevalence of hypertension, but reports are inconsistent for blood pressure (BP). To ascertain noise effects and to disentangle them from those suspected to be from traffic-related air pollution, it may be essential to estimate people's noise exposure indoors in bedrooms. Objectives: We analyzed associations between long-term exposure to indoor traffic noise in bedrooms and prevalent hypertension and systolic (SBP) and diastolic (DBP) BP, considering long-term exposure to outdoor nitrogen dioxide (NO2). Methods: We evaluated 1,926 cohort participants at baseline (years 2003-2006; Girona, Spain). Outdoor annual average levels of nighttime traffic noise (L-night) and NO2 were estimated at postal addresses with a detailed traffic noise model and a land-use regression model, respectively. Individual indoor traffic Lnight levels were derived from outdoor Lnight with application of insulations provided by reported noise-reducing factors. We assessed associations for hypertension and BP with multi-exposure logistic and linear regression models, respectively. Results: Median levels were 27.1 dB(A) (indoor Lnight), 56.7 dB(A) (outdoor Lnight), and 26.8 mu g/m(3) (NO2). Spearman correlations between outdoor and indoor Lnight with NO2 were 0.75 and 0.23, respectively. Indoor Lnight was associated both with hypertension (OR = 1.06; 95% CI: 0.99, 1.13) and SBP (beta = 0.72; 95% CI: 0.29, 1.15) per 5 dB(A); and NO2 was associated with hypertension (OR = 1.16; 95% CI: 0.99, 1.36), SBP (beta = 1.23; 95% CI: 0.21, 2.25), and DBP (beta = 0.56; 95% CI: -0.03, 1.14) per 10 mu g/m3. In the outdoor noise model, Lnight was associated only with hypertension and NO2 with BP only. The indoor noise-SBP association was stronger and statistically significant with a threshold at 30 dB(A). Conclusion: Long-term exposure to indoor traffic noise was associated with prevalent hypertension and SBP, independently of NO2. Associations were less consistent for outdoor traffic L-night and likely affected by collinearity.

99. **H. Nakaoka, E. Todaka, H. Seto, I. Saito, M. Hanazato, M. Watanabe and C. Mori**, **Correlating the symptoms of sick-building syndrome to indoor VOCs concentration levels and odour** (**2014**), Journal/Indoor and Built Environment, 23, 804-813.

Sick-building syndrome (SBS) is a range of symptoms such as eye irritation, sore throat, and headaches that occur when entering a newly constructed or refurbished building. Volatile organic compounds (VOCs) are suspected to be one of the major causes of SBS. However, although Ministry of Health, Labour, and Welfare of Japan set the guideline values for 13 VOCs, the incidences of SBS patients have not decreased. In addition, there have been reports that when people complained symptoms of SBS, most of them also claimed to smell an odour. Furthermore, the occurrence of SBS symptoms depends largely on the person's sensitivity. In this study, the correlation between the sum of VOCs(C2-C16) including aldehydes (sigma VOCs) and SBS symptoms were examined by statistics. The odour was quantified using the odour threshold ratio (OTR) and the correlation between the total odour threshold ratio (TOTR: sum of the OTR) and SBS symptoms was investigated. These correlations were examined separately for sensitive and insensitive groups. TOTR and the concentration level of sigma VOCs were correlated with SBS symptoms among sensitive people. The findings indicate that TOTR, in addition to sigma VOCs, could be used as a new risk indicator for human health regarding indoor air quality.

100. **N. C. Deziel, J. S. Colt, E. E. Kent, R. B. Gunier, P. Reynolds, B. Booth, C. Metayer and M. H. Ward**, **Associations between self-reported pest treatments and pesticide concentrations in carpet dust** (**2015**), Journal/Environmental Health, 14, 11.

Background: Recent meta-analyses demonstrate an association between self-reported residential pesticide use and childhood leukemia risk. Self-reports may suffer from recall bias and provide information only on broad pesticide categories. We compared parental self-reported home and garden pest treatments to pesticides measured in carpet dust. Methods: Parents of 277 children with leukemia and 306 controls in Northern and Central California (2001-2007) were asked about insect and weed treatments during the previous year. Carpet dust samples were analyzed for 47 pesticides. We present results for the 7 insecticides (carbaryl, propoxur, chlorpyrifos, diazinon, cyfluthrin, cypermethrin, permethrin), 5 herbicides (2,4-dichlorophenoxyacetic acid [2,4-D], chlorthal, dicamba, mecoprop, simazine), and 1 synergist (piperonyl butoxide) that were present in home and garden products during the study period and were detected in >= 25% of carpet dust samples. We constructed linear regression models for the relative change in pesticide concentrations associated with self-reported treatment of pest types in cases and controls separately and combined, adjusting for demographics, housing characteristics, and nearby agricultural pesticide applications. Results: Several self-reported treatments were associated with pesticide concentrations in dust. For example, households with flea/tick treatments had 2.3 (95% Confidence Interval [CI]: 1.4, 3.7) times higher permethrin concentrations than households not reporting this treatment. Households reporting treatment for ants/cockroaches had 2.5 (95% CI: 1.5, 4.2) times higher cypermethrin levels than households not reporting this treatment. Weed treatment by a household member was associated with 1.9 (1.4, 2.6), 2.2 (1.6, 3.1), and 2.8 (2.1, 3.7) times higher dust concentrations of dicamba, mecoprop, and 2,4-D, respectively. Weed treatments by professional applicators were null/inversely associated with herbicide concentrations in dust. Associations were generally similar between cases and controls and were consistent with pesticide active ingredients in these products during the study time period. Conclusions: Consistency between self-reported pest treatments, concentrations in dust, and pesticides in products lends credibility to the exposure assessment methods and suggests that differential recall by case-control status is minimal.

III.4   Sick Buildings Syndrome (SBS)

Pas d'article

III.5   Populations sensibles

101.   C. **E. Ciaccio, A. DiDonna, K. Kennedy, C. S. Barnes, J. M. Portnoy and L. J. Rosenwasser, Secondhand tobacco smoke exposure in low-income children and its association with asthma (2014), Journal/Allergy and Asthma Proceedings, 35, 462-466.**

Secondhand tobacco smoke (SHS) is a common indoor environmental exposure that is particularly prevalent, in low-income families. It has been found to be associated with asthma in some studies; however, across all relevant studies, results have been conflicting. This study aimed to determine the prevalence of SHS exposure in the home environment in a low-income, minority population and to determine the association of exposure with childhood asthma, wheeze, and oral,corticosteroids use. This retrospective study analyzed self-reported data collected as part of the Kansas City Safe and Healthy Homes Partnership to determine prevalence of SHS exposure. A logistic regression model was then used to assess the association between exposure and asthma, oral steroid use, and wheeze. Overall, 40% of children lived with at: least one smoker and 15% of children lived with at least one smoker who smoked inside the house. No significant association was found between asthma or oral corticosteroid use and SHS exposure. Children who lived with a smoker had a 1.54 increased odds of wheeze in the past year. A large percentage of low-income children in the Kansas City area contintie to suffer the adverse effects of SHS. These data support the need for innovative public policy to protect children from such eXposure in their home environment.

102.   **U. Franck, A. Weller, S. W. Roder, G. Herberth, K. M. Junge, T. Kohajda, M. von Bergen, U. Rolle-Kampczyk, U. Diez, M. Borte, I. Lehmann and N. A. Study Grp Li**, **Prenatal VOC exposure and redecoration are related to wheezing in early infancy** (**2014**), Journal/Environment International, 73, 393-401.

Redecoration of dwellings is a common behavior of expecting parents. Former studies gave evidence that early childhood exposure to volatile organic compounds (VOC) resulting from renovation activities may increase the risk for wheeze in infants. Objectives: The aim of the present study was to evaluate the impact of prenatal exposure on early wheeze and to identify sensitive time windows. Within the LINA birth cohort study data on renovation activities and respiratory outcomes were assessed via questionnaires during pregnancy and at children's age of one. At both timepoints, also indoor VOC concentrations were measured. The associations were studied by logistic regression analysis. Floor covering during pregnancy contributed to an increased risk for physician treated wheeze (adjusted odds ratio OR = 5.20,95% confidence interval 1.8-15.2) during the first 12 months after birth in particular in children with an atopic predisposition. Thereby, wall-to-wall-carpets, PVC material, and laminate were the flooring materials which showed the strongest adverse associations. Floor covering was associated with enhanced concentrations of VOCs in the apartments. For the VOCs styrene, ethylbenzene, octane, 1-butanol, tridecane, and o-xylene, a significant association was found to the occurrence of wheezing symptoms. In contrast to pregnancy, exposure during the first 12 months after birth showed less detrimental associations. Only the association between wheezing and styrene as well as between wheezing and PVC flooring remained significant for exposure after birth. Redecoration during pregnancy, especially changing floor materials, increases the risk for

respiratory diseases in early childhood and should therefore be avoided at least in families with a history of atopic diseases. (C) 2014 Elsevier Ltd. All rights reserved.

103. **J. Fonseca, K. Slezakova, S. Morais and M. C. Pereira**, **Assessment of ultrafine particles in Portuguese preschools: levels and exposure doses** (**2014**), Journal/Indoor Air, 24, 618-628.

The aim of this work was to assess ultrafine particles (UFP) number concentrations in different microenvironments of Portuguese preschools and to estimate the respective exposure doses of UFP for 3-5-year-old children (in comparison with adults). UFP were sampled both indoors and outdoors in two urban (US1, US2) and one rural (RS1) preschool located in north of Portugal for 31days. Total levels of indoor UFP were significantly higher at the urban preschools (mean of 1.82x10(4) and 1.32x10(4)particles/cm(3) at US1 an US2, respectively) than at the rural one (1.15x10(4)particles/cm(3)). Canteens were the indoor microenvironment with the highest UFP (mean of 5.17x10(4), 3.28x10(4), and 4.09x10(4)particles/cm(3) at US1, US2, and RS1), whereas the lowest concentrations were observed in classrooms (9.31x10(3), 11.3x10(3), and 7.14x10(3)particles/cm(3) at US1, US2, and RS1). Mean indoor/outdoor ratios (I/O) of UFP at three preschools were lower than 1 (0.54-0.93), indicating that outdoor emissions significantly contributed to UFP indoors. Significant correlations were obtained between temperature, wind speed, relative humidity, solar radiation, and ambient UFP number concentrations. The estimated exposure doses were higher in children attending urban preschools; 3-5-year-old children were exposed to 4-6 times higher UFP doses than adults with similar daily schedules.

III.6　*Évaluation des risques*

Rubrique N°19

104. **G. M. Lehmann, K. Christensen, M. Maddaloni and L. J. Phillips**, **Evaluating Health Risks from Inhaled Polychlorinated Biphenyls: Research Needs for Addressing Uncertainty** (**2015**), Journal/Environmental Health Perspectives, 123, 109-113.

Background: Indoor air concentrations of polychlorinated biphenyls (PCBs) in some buildings are one or more orders of magnitude higher than background levels. In response to this, efforts have been made to assess the potential health risk posed by inhaled PCBs. These efforts are hindered by uncertainties related to the characterization and assessment of source, exposure, and exposure-response. Objectives: We briefly describe some common sources of PCBs in indoor air and estimate the contribution of inhalation exposure to total PCB exposure for select age groups. Next, we identify critical areas of research needed to improve assessment of exposure and exposure response for inhaled PCBs. Discussion: Although the manufacture of PCBs was banned in the United States in 1979, many buildings constructed before then still contain potential sources of indoor air PCB contamination. In some indoor settings and for some age groups, inhalation may contribute more to total PCB exposure than any other route of exposure. PCB exposure has been associated with human health effects, but data specific to the inhalation route are scarce. To support exposure-response assessment, it is critical that future investigations of the health impacts of PCB inhalation carefully consider certain aspects of study design, including characterization of the PCB mixture present. Conclusions: In certain contexts, inhalation exposure to PCBs may contribute more to total PCB exposure than previously assumed. New epidemiological and toxicological studies addressing the potential health impacts of inhaled PCBs may be useful for quantifying exposure-response -relationships and evaluating risks.

105. **A. Traumann, K. Reinhold and P. Tint**, **ENVIRONMENTAL AND OCCUPATIONAL IMPACT ON HUMAN HEALTH OF DUST AND CHEMICALS FROM MODERN TECHNOLOGIES** (**2014**), Journal/Environmental Engineering and Management Journal, 13, 2233-2241.

The paper concentrates on the risks of modern technologies (in wood processing and metal industry, spray-painting processes and car washing technologies) in the industrial and office environments on human health. The problems discussed are the following: fine dust (PM(2.5)and PM1.0) penetrating deeply into the lungs; high concentration of carbon dioxide in the air of cities and office areas that are situated close to the transport junctions. The health damages can be described as follows: allergic reactions, hypersensitivity to the bacteria and viruses from the environment; headaches and fatigue; decreased work-life and early retirement. The measurements in the indoor and outdoor environment of carbon dioxide, chemicals and dust were carried out in and near the industrial premises and office-rooms in Estonia. Health risk levels in the industrial and office environments were determined using the worked out simple risk assessment model (connected with the standard EVS-EN 15251) by the authors. The most emphasized problem is the Estonian woodworkers' exposure to wood dust. The wood dust concentration in the air of nearby residential areas has been determined. On the basis of the Estonian legislation, the measurements and the literature data on wood dust hazardousness, the model for determination of wood dust risk levels is worked out. The risk level of wood dust in the example of Estonian wood-processing industry is III to IV in the five levels scale. On the basis of the investigation it has been concluded that the working conditions in the wood processing industry in Estonia in 2011-2012 have been improved compared with the earlier time period (1999-2000). The better working conditions have been achieved mainly by installing more effective ventilation systems and consistent cleaning of the work areas.

IV. GESTION / DIVERS

IV.1 Systèmes de ventilation

Rubrique N°20

REVIEW

106. **H. Arvela, O. Holmgren, H. Reisbacka and J. Vinha**, **REVIEW OF LOW-ENERGY CONSTRUCTION, AIR TIGHTNESS, VENTILATION STRATEGIES AND INDOOR RADON: RESULTS FROM FINNISH HOUSES AND APARTMENTS** (**2014**), Journal/Radiation Protection Dosimetry, 162, 351-363.

Low-energy and passive house construction practices are characterised by increased insulation, high air tightness of the building shell and controlled mechanical ventilation with heat recovery. As a result of the interaction of mechanical ventilation and high air tightness, the pressure difference in a building can be markedly enhanced. This may lead to elevated indoor radon levels. Minor leakages in the foundation can affect the radon concentration, even in the case where such leaks do not markedly reduce the total air tightness. The potential for high pressures to affect indoor radon concentrations markedly increases when the air tightness ACH(50), i.e. the air change per hour induced by a pressure difference of 50 Pa, is <1.0 h(-1). Pressure differences in Finnish low-rise residential houses having mechanical supply and exhaust ventilation with heat recovery (MSEV) are typically 2-3 Pa, clearly lower than the values of 5-9 Pa in houses with only mechanical exhaust ventilation (MEV). In MSEV houses, radon concentrations are typically 30 % lower than in MEV houses.

In new MSEV houses with an ACH(50) of 0.6 h(-1), the limit for passive construction, the analytical estimates predict an increase of 100 % in the radon concentration compared with older houses with an ACH(50) of 4.0 h(-1). This poses a challenge for efficient radon prevention in new construction. Radon concentrations are typically 30 % lower in houses with two storeys compared with only one storey. The introduction of an MSEV ventilation strategy in typically very airtight apartments has markedly reduced pressure differences and radon concentrations.

107. **S. Soutullo, R. Enriquez, M. J. Jimenez and M. R. Heras**, **Thermal comfort evaluation in a mechanically ventilated office building located in a continental climate** (**2014**), Journal/Energy and Buildings, 81, 424-429.

To quantify the thermal comfort achieved in an office building placed in Madrid and considering climatic variations, building designs, behaviour of inhabitants and the operation of the conditioning systems, two experimental campaigns have been carried out during the summer and the wintertime. Depending on the season of the year different temperature profiles have been obtained as a consequence of meteorological variables and inhabitant concerns. Energy balance between indoors and outdoors indicate the thermal oscillation as well as the thermal deviation from the comfort bands. To analyze the daily evolution two typical days have been calculated by the Hall methodology. The quantification of thermal sensation of the occupants has been calculated by the PMV/PPD methodology. This evaluation shows low percentages of people dissatisfied with the indoor environments and low energy demands achieved inside the offices. (C) 2014 Elsevier B.V. All rights reserved.

IV.2   Analyse coût-bénéfice

Rubrique N°21

108. **A. Chaudhary and S. Hellweg**, **Including Indoor Offgassed Emissions in the Life Cycle Inventories of Wood Products** (**2014**), Journal/Environmental Science & Technology, 48, 14607-14614.

Volatile organic compounds (VOCs) that negatively affect human health are emitted from wood products used indoors. However, the existing life cycle inventories of these products only document the emissions occurring during production and disposal phases. Consequently, the life cycle assessment (LCA) of indoor wooden products conducted using these inventories neglect the use-phase impacts from exposure to offgassed VOCs and therefore underestimate the products total environmental impact. This study demonstrates a methodology to calculate the use phase inventory and the corresponding human health impacts resulting from indoor use of any VOC emitting product. For the five most commonly used types of boards used in indoor wood products, the mass of each VOC emitted into the indoor compartment over their service life was calculated by statistically analyzing data from 50 published chamber testing studies. Uncertainty was assessed using Monte Carlo simulations. The calculated inventory data were used in a case study to calculate and compare the health impacts of five different wooden floorings made of above materials. The results show that the use-phase human-toxicity impacts are an order of magnitude higher than those occurring during the rest of the floorings life cycle. The factors influencing the offgassing of VOCs from wood products and measures to reduce exposure are discussed.

IV.3   Technique

Rubrique N°22

109.   **A. Gandolfo, V. Bartolomei, E. G. Alvarez, S. Tlili, S. Gligorovski, J. Kleffmann and H. Wortham**, **The effectiveness of indoor photocatalytic paints on NOx and HONO levels** (**2015**), Journal/Applied Catalysis B-Environmental, 166, 84-90.

There is an increasing concern about the indoor air environment, where we spend most of our time. Common methods of improving indoor air quality include controlling pollution sources, increasing ventilation rates or using air purifiers. Photocatalytic remediation technology was suggested as a new possibility to eliminate indoor air pollutants instead of just diluting or disposing them. Titanium dioxide (TiO2) is a widely used photocatalyst, which is aimed to eliminate organic and inorganic pollutants. Here, we demonstrate that indoor photocatalytic paints which contain TiO2 can substantially reduce the concentrations of nitrogen dioxide (NO2). We show that the efficiency of nitrogen dioxide (NO2) removal increases with the quantity of TiO2 in the range 0-7%. The geometric uptake coefficients increase from 5 x 10(-6) to 1.6 x 10(-5) under light irradiation of the paints. On the other hand, during the reactions of NO2 with this paint (7% of TiO2) nitric oxide (NO) and nitrous acid (HONO) are formed. Nitrous acid (HONO) is an important harmful indoor pollutant and its photolysis leads to the formation of highly reactive OH radicals. Maximum conversion efficiencies of NO2 to MONO and NO of 15% and 33% were observed at 30% RH, respectively. A dynamic mass balance model applied to typical indoor environment predicts a steady state mixing ratio of 5.6 ppb of MONO released upon light-induced surface reaction of NO2 with a photocatalytic paint (7% of TiO2) and considering the photolysis process as the most important loss of MONO. The quantity of TiO2 embedded in the paint is of crucial importance with respect to nitrogen oxides NO2 remediation, but may also influence the formation of harmful intermediates like nitrous acid (MONO), which should be considered for future optimization of photocatalytic paints aimed for indoor applications. (C) 2014 Elsevier B.V. All rights reserved.

110.   **K. Abedi, F. Ghorbani-Shahna, B. Jaleh, A. Bahrami, R. Yarahmadi, R. Haddadi and M. Gandomi**, **Decomposition of chlorinated volatile organic compounds (CVOCs) using NTP coupled with TiO2/GAC, ZnO/GAC, and TiO2-ZnO/GAC in a plasma-assisted catalysis system** (**2015**), Journal/Journal of Electrostatics, 73, 80-88.

No study was found in the literature on the catalytic effect of TiO2/GAC (Granular activated carbon), ZnO/ GAC, and TiO2 ZnO/GAC combined with non-thermal plasma (NTP) for the decomposition of chlorinated volatile organic compounds (CVOCs) in gas streams. In the present study, this catalytic NTP process was investigated to examine the effect of specific input energy (SIE), initial concentration, as well as residence time on the removal efficiency (RE) of CVOCs in a corona discharge reactor energized by a high frequency pulsed power supply. A dip-coating sol gel impregnation technique was used to coat TiO2, ZnO, and mixture of TiO2 ZnO nanoparticles on GAC, which were then combined with NI? in a two-stage configuration. The results revealed that the efficacy of the catalysts was in the order TiO2 ZnO/ GAC Ti02/GAC > ZnO/GAC with chloroform feeding, while when chlorobenzene introduced, the order changed to Ti02 ZnO/GAC > ZnO/GAC > Ti02/GAC. A significant enhancement was observed with RE as catalysts coupled with NTP in all cases and a RE of 100% was achieved in the presence of both Ti02/GAC and Ti02 ZnO/GAC at SIE of ca. 400 J L. Considerable improvement was also noticed for coupling TiO2 and ZnO in both efficiency and catalyst life time. (C) 2014 Elsevier B.V. All rights reserved.

111.   **J. W. Li, K. L. Pan, S. J. Yu, S. Y. Yan and M. B. Chang**, **Removal of formaldehyde over MnxCe1-xO2 catalysts: Thermal catalytic oxidation versus ozone catalytic oxidation** (**2014**), Journal/Journal of Environmental Sciences-China, 26, 2546-2553.

MnxCe1-xO2 (x: 0.3-0.9) prepared by Pechini method was used as a catalyst for the thermal catalytic oxidation of formaldehyde (HCHO). At x = 0.3 and 0.5, most of the manganese was incorporated in the fluorite structure of CeO2 to form a solid solution. The catalytic activity was best at x = 0.5, at which the temperature of 100% removal rate is the lowest (270 degrees C). The temperature for 100% removal of HCHO oxidation is reduced by approximately 40 degrees C by loading 5 wt.% CuOx into Mn0.5Ce0.5O2. With ozone catalytic oxidation, HCHO (61 ppm) in gas stream was completely oxidized by adding 506 ppm O-3 over Mn0.5Ce0.5O2 catalyst with a GHSV (gas hourly space velocity) of 10,000 hr(-1) at 25 degrees C. The effect of the molar ratio of O-3 to HCHO was also investigated. As O-3/HCHO ratio was increased from 3 to 8, the removal efficiency of HCHO was increased from 83.3% to 100%. With 03/HCHO ratio of 8, the mineralization efficiency of HCHO to CO2 was 86.1%. At 25 degrees C, the p-type oxide semiconductor (Mn0.5Ce0.5O2) exhibited an excellent ozone decomposition efficiency of 99.2%, which significantly exceeded that of n-type oxide semiconductors such as TiO2, which had a low ozone decomposition efficiency (9.81%). At a GHSV of 10,000 hr(-1), [O-3]/[HCHO] = 3 and temperature of 25 degrees C, a high HCHO removal efficiency (>= 81.2%) was maintained throughout the durability test of 80 hr, indicating the long-term stability of the catalyst for HCHO removal. (c) 2014 The Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences. Published by Elsevier B.V.

112.   **J. G. Su, M. Jerrett, Y. Y. Meng, M. Pickett and B. Ritz**, **Integrating smart-phone based momentary location tracking with fixed site air quality monitoring for personal exposure assessment** (**2015**), Journal/Science of the Total Environment, 506, 518-526.

Epidemiological studies investigating relationships between environmental exposures from air pollution and health typically use residential addresses as a single point for exposure, while environmental exposures in transit, at work, school or other locations are largely ignored. Personal exposure monitors measure individuals' exposures over time; however, current personal monitors are intrusive and cannot be operated at a large scale over an extended period of time (e.g., for a continuous three months) and can be very costly. In addition, spatial locations typically cannot be identified when only personal monitors are used. In this paper, we piloted a study that applied momentary location tracking services supplied by smart phones to identify an individual's location in space-time for three consecutive months (April 28 to July 28, 2013) using available Wi-Fi networks. Individual exposures in space-time to the traffic-related pollutants Nitrogen Oxides (NOx) were estimated by superimposing an annual mean NOx concentration surface modeled using the Land Use Regression (LUR) modeling technique. Individuals exposures were assigned to stationary (including home, work and other stationary locations) and in-transit (including commute and other travel) locations. For the individual, whose home/work addresses were known and the commute route was fixed, it was found that 95.3% of the time, the individual could be accurately identified in space-time. The ambient concentration estimated at the home location was 21.01 ppb. When indoor/outdoor infiltration, indoor sources of air pollution and time spent outdoors were taken into consideration, the individual's cumulative exposures were 28.59 ppb and 96.49 ppb, assuming a respective indoor/outdoor ratio of 133 and 5.00. Integrating momentary location tracking services with fixed-site field monitoring, plus indoor-

outdoor air exchange calibration, makes exposure assessment of a very large population over an extended time period feasible. (C) 2014 Elsevier B.V. All rights reserved.

113. **R. A. Raso, M. Zeltner and W. J. Stark**, **Indoor Air Purification Using Activated Carbon Adsorbers: Regeneration Using Catalytic Combustion of Intermediately Stored VOC** (**2014**), Journal/Industrial & Engineering Chemistry Research, 53, 19304-19312.

In this study, we demonstrate a two-step process where activated carbon based air purifier systems can be regenerated in situ and eliminate volatile organic compounds (VOCs) from indoor air in an energy efficient way. A carbon based adsorber was combined in series with a CeO2/TiO2 oxidative catalyst for total oxidation of the previously adsorbed and periodically released volatile organic compounds during regeneration runs. We investigated the adsorption and desorption behavior of five different VOCs (diethyl ether, limonene, linalool, hexanoic acid, triethylamine and n-decane) with thermogravimetric measurements, mass spectrometry and elemental analysis. Cyclic loading and regeneration experiments were carried out with selected VOCs (limonene, linalool and n-decane) for testing regeneration at elevated temperature. We showed that in situ thermal regeneration and subsequent oxidation of released VOC is a sustainable and easy applicable technology for indoor air purification. This two-step approach allows energy saving as the VOCs are eliminated discontinuously (enriching VOCs; periodic catalytic combustion), and is of high environmental and economic interest, as much less maintenance services are required.

114. **P. Azimi, D. Zhao and B. Stephens**, **Estimates of HVAC filtration efficiency for fine and ultrafine particles of outdoor origin** (**2014**), Journal/Atmospheric Environment, 98, 337-346.

This work uses 194 outdoor particle size distributions (PSDs) from the literature to estimate single-pass heating, ventilating, and air-conditioning (HVAC) filter removal efficiencies for PM2.5 and ultrafine particles (UFPs: <100 nm) of outdoor origin. The PSDs were first fitted to tri-modal lognormal distributions and then mapped to size-resolved particle removal efficiency of a wide range of HVAC filters identified in the literature. Filters included those with a minimum efficiency reporting value (MERV) of 5, 6, 7, 8, 10, 12, 14, and 16, as well as HEPA filters. We demonstrate that although the MERV metric defined in ASHRAE Standard 52.2 does not explicitly account for UFP or PM2.5 removal efficiency, estimates of filtration efficiency for both size fractions increased with increasing MERV. Our results also indicate that outdoor PSD characteristics and assumptions for particle density and typical size-resolved infiltration factors (in the absence of HVAC filtration) do not drastically impact estimates of HVAC filter removal efficiencies for PM2.5. The impact of these factors is greater for UFPs; however, they are also somewhat predictable. Despite these findings, our results also suggest that MERV alone cannot always be used to predict UFP or PM2.5 removal efficiency given the various size-resolved removal efficiencies of different makes and models, particularly for MERV 7 and MERV 12 filters. This information improves knowledge of how the MERV designation relates to PM2.5 and UFP removal efficiency for indoor particles of outdoor origin. Results can be used to simplify indoor air quality modeling efforts and inform standards and guidelines. (C) 2014 Elsevier Ltd. All rights reserved.

115. **M. Gruber, A. Truschel and J. O. Dalenback**, **CO2 sensors for occupancy estimations: Potential in building automation applications** (**2014**), Journal/Energy and Buildings, 84, 548-556.

It is well established that model-based controllers with an integrated control model and information about indoor climate disturbances have the ability to drastically improve the performance of building automation systems. In offices, occupancy is one of the most important disturbances to account for in this context, but the available methods for accurately

determining the number of people are commonly too complex for considering at most sites. However, since model-based controllers can be made robust, input deficiencies can to a certain degree be compensated for, and in this work, a two step procedure was applied to investigate the potential of utilizing simplified estimations generated from CO_2 sensor responses. First, the expected time delay and error of such estimations were derived experimentally for various occupancy changes and ventilation flow rates. Next, an office site was simulated and the occupancy information used by a model-based controller for ventilation control was stepwise subjected to various errors and time delays by considering the expected values as references. The results showed that the estimations in many case were sufficient for achieving a high control performance, but beyond a certain level, the deficiencies could only be met by an increased complexity of the controller. (C) 2014 Elsevier B.V. All rights reserved

IV.4 Réglementaire

Rubrique N°23
Pas d'article

IV.5 Divers

Pas d'article

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