# Cumulative indoor exposures to Semi-Volatile Organic Compounds (SVOCs) in France: contamination levels in thirty French schools

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## CONTEXT & AIMS OF THE WORK

The use of new building materials, furnishings, and consumer products has resulted in a corresponding increase in new chemicals like Semi-volatile Organic Compounds (SVOCs) in the built environment. People spend most of their time (approximately 90%) in indoor environment, including homes, workplaces, schools…. Indoor routes to SVOCs occur via inhalation, ingestion and dermal pathways. Because of their behavior, young children are often more vulnerable; however their indoor exposures to SVOCs and associated health risks have not been investigated in France yet.

This study focused on SVOC contamination of air and settled dust in 30 schools. It aimed at validating sampling and analysis methods prior to a nationwide survey in schools to be implemented by the French Observatory of Indoor air quality (OQAI).

## MATERIAL & METHODS

Selection of compounds. Fifty five compounds were selected on the basis of their potential health effects (Bonvallot N. et al, Indoor air 2010) and analytical feasibility in one multi-residue analysis (Mercier F. ,Thesis 2011).

Samples collection. Ninety classrooms from thirty primary schools were investigated in Brittany, France, from October 2009 to June 2010.

Sampling methods. Air samples (12 m³) were collected by active sampling on glass cartridges fitted with quartz fiber filter and polyurethane foam (PUF) during 5 days. Settled dust was sampled: 1) on a measured area with a modified vacuum cleaner and 2) with 3 wipes (on 0.1 m² each) in each classroom (Fig.1).

Extraction methods. Air samples (PUF and filters together) were extracted with dichloromethane using pressurized liquid extraction. After sieving at 100µm, 200mg of vacuumed dust samples were extracted with dichloromethane using pressurized liquid extraction. Wipe dust samples were extracted by sonication with dichloromethane (Fig.1).

Analytical method. Samples extracts were analyzed by gas chromatography coupled with tandem mass spectrometry (GC/MS/MS).

Validation of the analytical procedures. Calibration curves were obtained with five levels of concentration. The mass spectrometer was operated in MRM mode (multiple reaction monitoring), using the two highest precursor ion/product ion transitions of each compounds. A blank and a standard reference material (SRM 2585) were analyzed for each sequence samples extraction and internal standards were added in each sample extract.

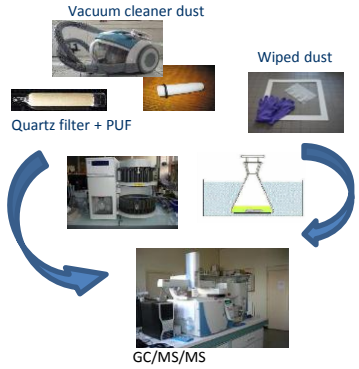
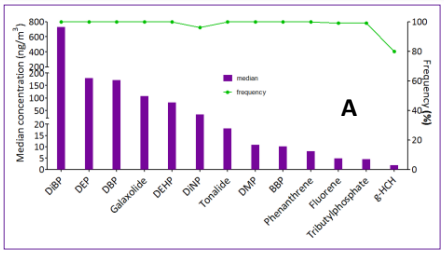
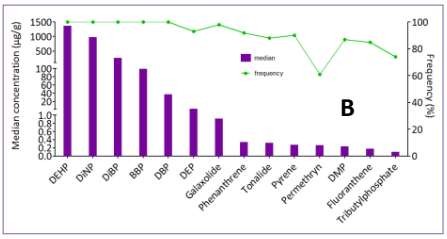



**Fig. 1** extraction and analytical methods



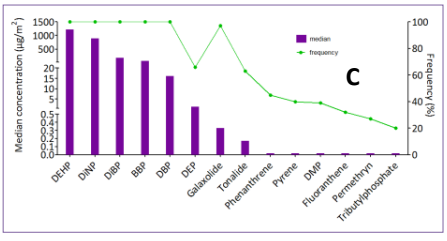




***Fig. 2:*** *Svoc frequency of quantification and concentrations in indoor air (gaz phase and PM)* ***A****, in dust (vacuum cleaner)* ***B****, in dust (wipes)* ***C****.*

**Organochlorine pesticides**
Aldrin, cis and trans-chlordane, 4,4'-DDE, 4,4'-DDT, dieldrin, alpha-endosulfan, endrin, heptachlor, α-HCH, γ-HCH and metolachlor

**Organophosphate pesticides**
Chlorpyrifos, diazinon and dichlorvos

**Pyrethroid pesticides**
Cyfluthrin, cypermethrin, deltamethrin, permethrin, tetramethrin

**Organophosphate esters**
Tributylphosphate

**Musks**
Galaxolide (HHCB) and tonalide (AHTN)

**Polycyclic aromatic hydrocarbons (PAHs)**
Acenaphtene, anthracene, benzo[a]pyrene, fluoranthene, fluorene, phenanthrene and pyrene

**Polychlorobiphenyls (PCBs)**
PCB 28, 31, 52, 77, 101, 105, 118, 126, 138, 153, and 180

**Phthalates**
BBP, DBP, DEHP, DEP, DiBP, DiNP, DMEP , DMP

**Polybrominated diphenyl ethers (PBDEs)**
BDE-85, 99, 100 and 119 (penta)

**Other pesticides** : Atrazine and oxadiazon

## RESULTS

Ten molecules were never detected in samples (neither in air nor in dust): cis-chlordane, heptachlor, metolachlor, atrazine, cyfluthrin, deltamethrin, tetramethrin, PCB 126, BDE 85 and BDE 119.

Air samples.

38 compounds were quantified. The highest concentrations (median concentrations > 50 ng/m³) were measured for some phthalates and the galaxolide (DiBP> DBP> DEP> DEHP> galaxolide). The intermediate concentrations (1-50 ng/m³) were measured for DiNP> tonalide> DMP> BBP> phenanthrene> fluorene> tributylphosphate> γ-HCH.

Dust samples.

42 compounds were quantified in dust sampled with vacuum cleaner. The highest concentrations (median concentrations > 5 µg/g) were measured for DEHP> DiNP> DiBP> BBP> DBP. The intermediate concentrations (0.1-3 µg/g) were measured for DEP> galaxolide> phenanthene> tonalide> pyrene> permethrin> DMP> fluoranthene> tributylphosphate.

34 compounds were quantified in dust sampled with wipes. The highest concentrations (median concentrations > 10 µg/m²) were measured for phthalates DEHP> DiNP> DiBP> BBP> DBP.

SVOC concentrations (µg/m²) were higher in wiped dust than in vacuumed dust. However the mass of collected dust was more important with the vacuum cleaner, thus allowing to detect more compounds.

## CONCLUSION

**School indoor air and dust were contaminated by SVOCs in a large range of concentrations, with higher levels for musks and some phthalates. For wipe samples, an area of 0.1 m² sampling is sufficient for the analysis of phthalates, but not for other compounds.**

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