



EHESP

LERES
ANALYSES - RECHERCHE



CHARACTERIZATION OF INDOOR AIR QUALITY IN VARIOUS SPORTS FACILITIES (QAI-SPORT PROJECT)

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1. CONTEXT

Physical activity

- ✓ one of the basic functions of human beings
- ✓ contributes to their health and well-being
- ✓ 2.5 h/week of moderately intense sporting activity (WHO recommendation for adults)

Sharp rise in the number of indoor sports facilities



IAQ still little known and little studied



Fitness (Europe, 2022):
63 millions memberships, 64 000 clubs (Deloitte, 2023)

Increase risk of exposure

IAQ degradation factors

inhalation
dust ingestion
dermal contact



Emitting materials
VOCs
SVOCs
Emerging pollutants



Occupancy rate



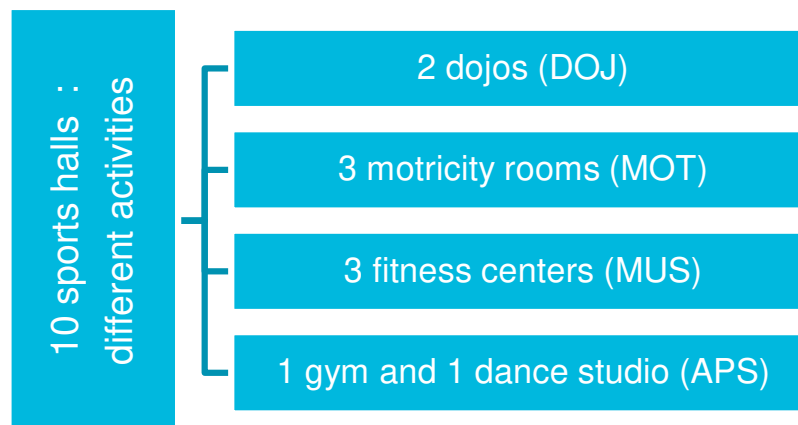
Biological contamination
(mould, bacteria, viruses)



2. OBJECTIVE

Characterize human exposure to chemical and microbiological contaminants in sports halls

1- Characterisation of IAQ of 10 sports halls



➡ In non-occupancy and occupancy conditions

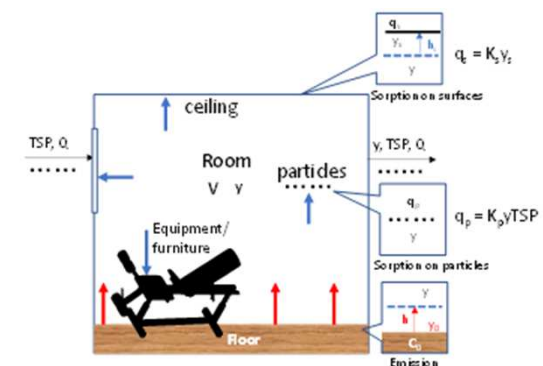
➡ Targeted and non-targeted analyzes of air and dust to identify and quantify known and regulated pollutants but also emerging pollutants (SVOC, unregulated VOCs, microorganisms including SARS-CoV-2)

2- Identification of contaminants sources

and understanding of their transfer and distribution in indoor environments (between air, surfaces, particles) in 3 selected sports halls

3- Exposure characterization

Information on routes of exposure by inhalation, by dermal contact, by ingestion of dust



3. METHODOLOGY

IAQ characterization: two 5 days-campaigns (Nov. 2022 – Ap. 2023)

- Unoccupied (vac) and occupied (occ) rooms
- Targeted and non-targeted analyses of air and dust
- Measurements of T, RH, P, CO₂ (→ air exchange rate)

	Monday	Tuesday	Wednesday	Thursday	Friday
IAQ parameters measurements					
COSV sampling in air (URG)					
COV sampling in air (Carbograph4)					
Carbonyls sampling in air (DNPH)					
Acids sampling in air (bubbling solution)					
μ-organisms sampling in air (cyclonic)					
μ-organisms sampling in air (bioimpaction)					
Settled dust sampling (vacuum cleaner)					

IAQ parameters



Air analysis



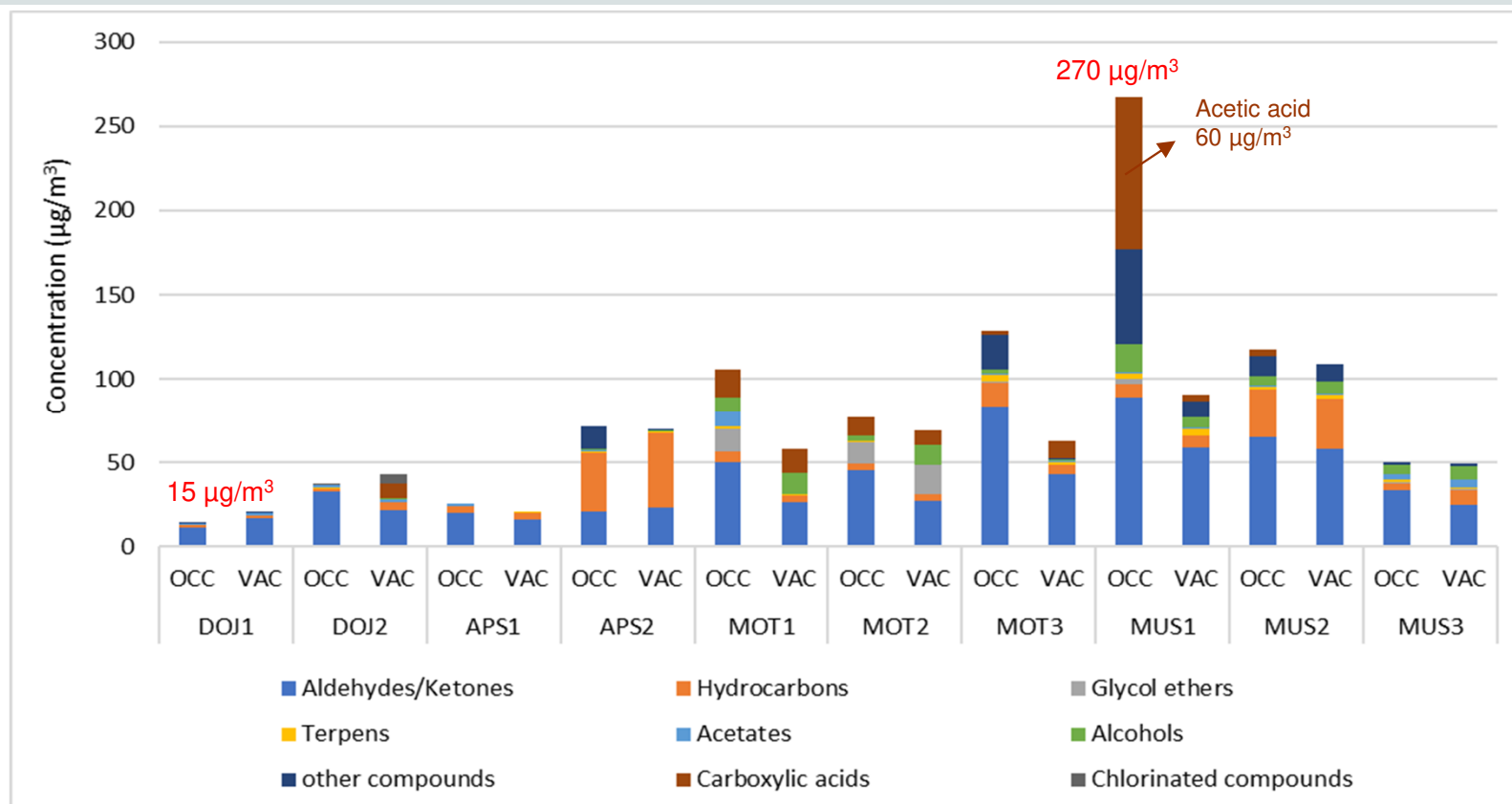
Dust analysis



3. METHODOLOGY

VOC		SVOC		Microorganisms	
IMT Mines Alès École Mines-Télécom		EHESP		EHESP	
Sampling <ul style="list-style-type: none"> • C4 cartridge • DNPH cartridge • H₂O bubbling 	Analysis <p>ATD-GC-MS-FID HPLC-UV IC-conductivity</p>	Sampling <ul style="list-style-type: none"> • Air : URG (PUF+QFF) • Settled dust : cellulose cartridge + sieving at 100 µm 	Analysis <p>GC-MS-MS</p>	Sampling <ul style="list-style-type: none"> • Cyclonic collection • Bioimpaction 	Analysis <ul style="list-style-type: none"> • ARN extraction (virus) – RT-qPCR detection • UFC numeration + identification (bacteria + molds)

4. VOC RESULTS IN AIR



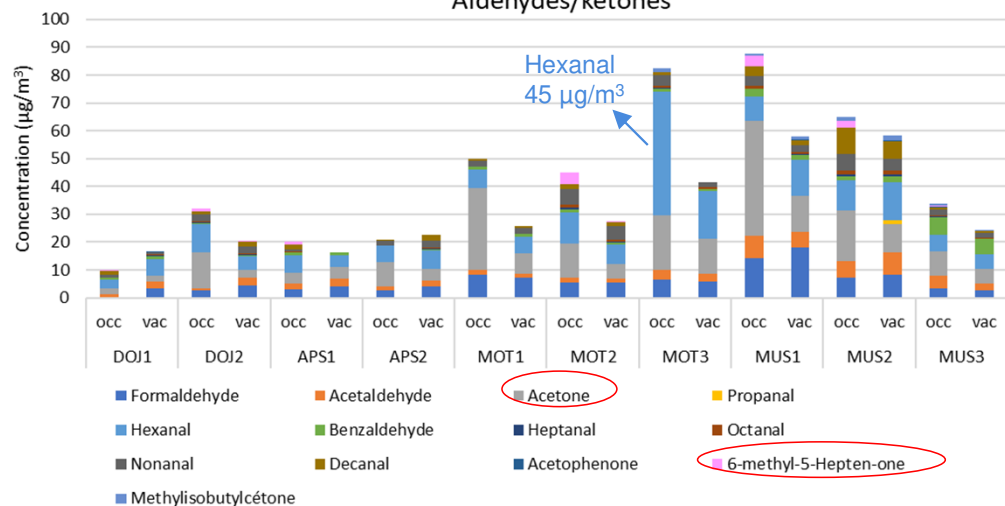
Sum of VOC per family
in the air of the 10
occupied and non-
occupied sports halls

- **53 VOC** quantified
- Low VOC concentrations measured in air
- **Carbonyl** compounds mostly present in all rooms

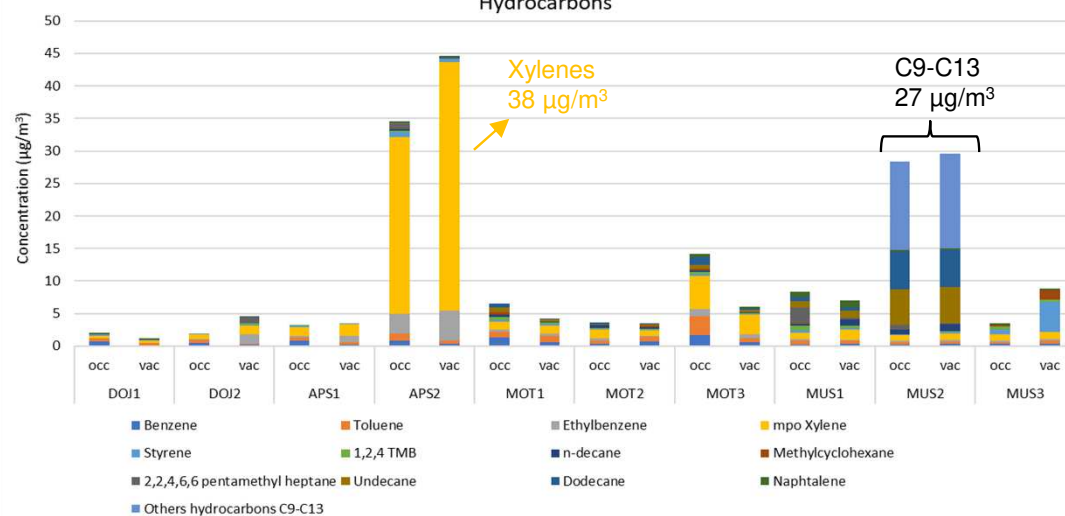
4. VOC RESULTS IN AIR

7

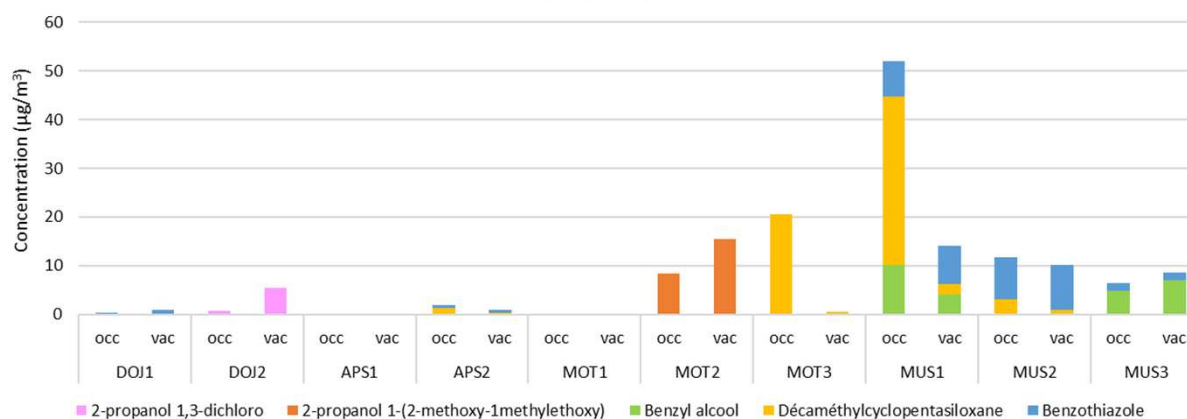
Aldehydes/ketones



Hydrocarbons



Emerging compounds



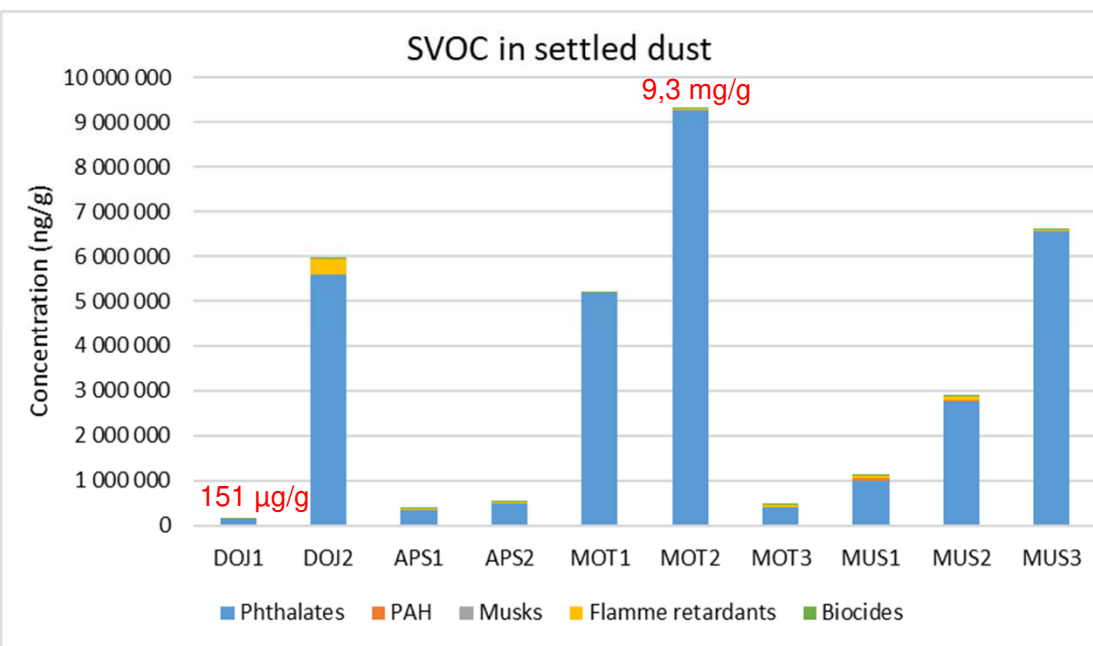
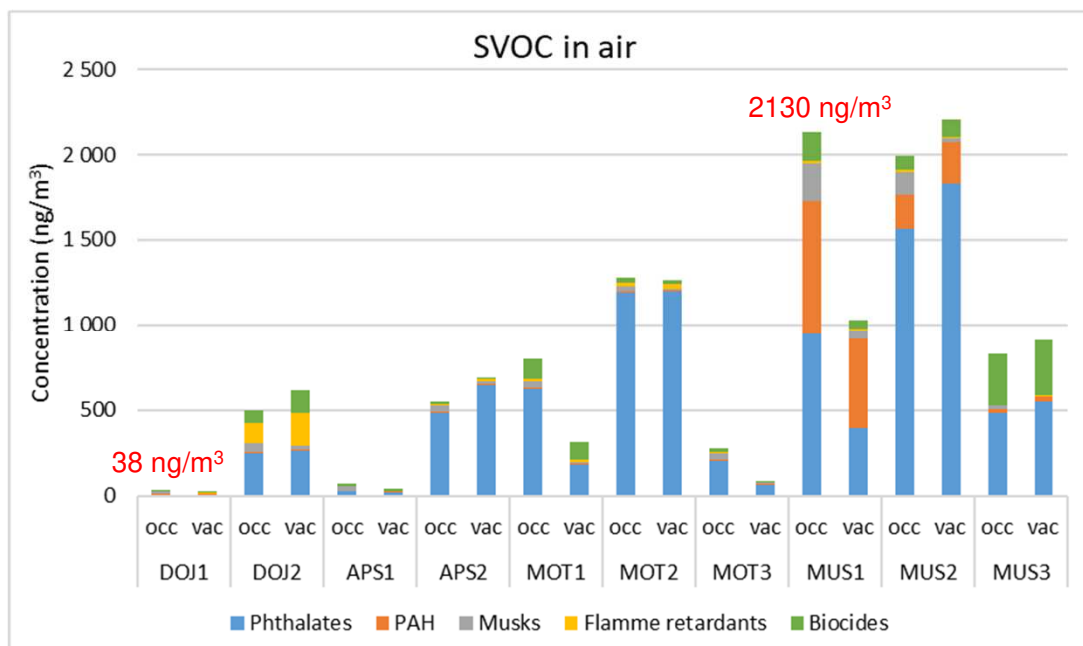
Identification of emerging compounds, emitted by materials or by human body (occupancy tracers)

5. SVOC RESULTS IN AIR AND SETTLED DUST



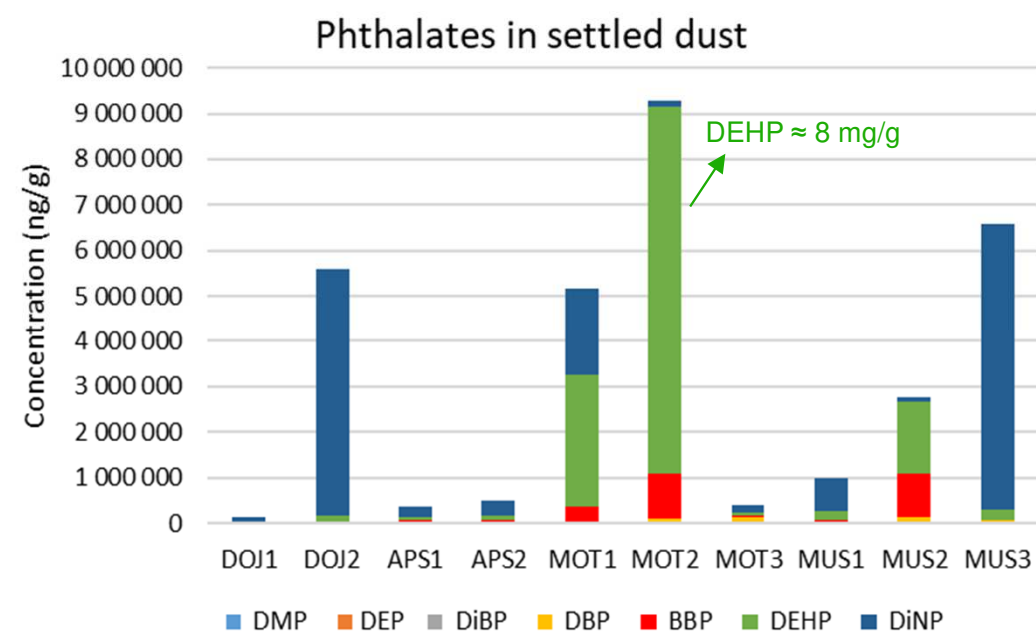
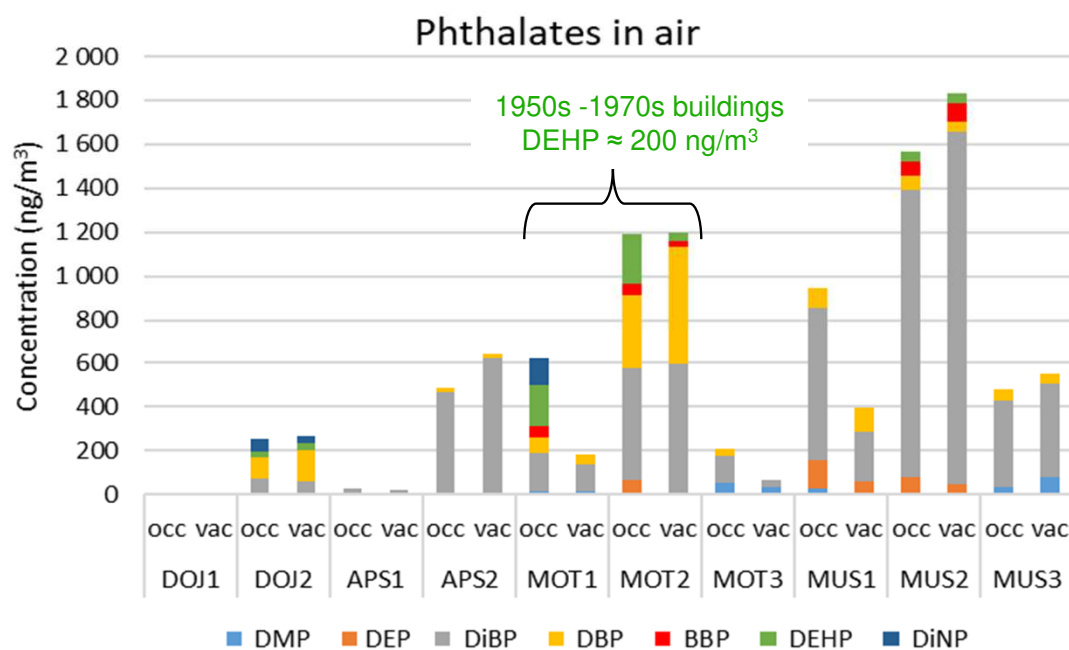
Atmos'Fair- 09/10/2024

8



- SVOC contamination was dominated by **phthalates** in air and settled dust
- SVOC cumulative concentrations in air and settled dust are lowest in DOJ1
- Phthalates exceeding the mg/g in the settled dust in 6 sports halls, and nearly 10 mg/g in MOT2

5. SVOC RESULTS IN AIR AND SETTLED DUST

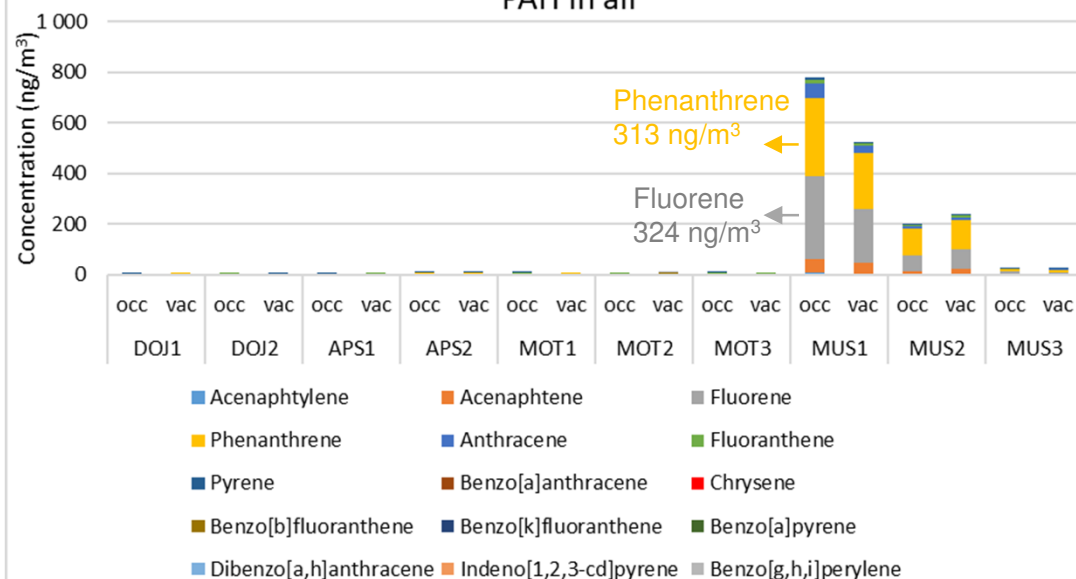


- The main compounds are different in air and settled dust
- **DiBP** and **DBP** are the most present in air
- **DiNP** and **DEHP** (banned since 2011) are the most present in settled dust

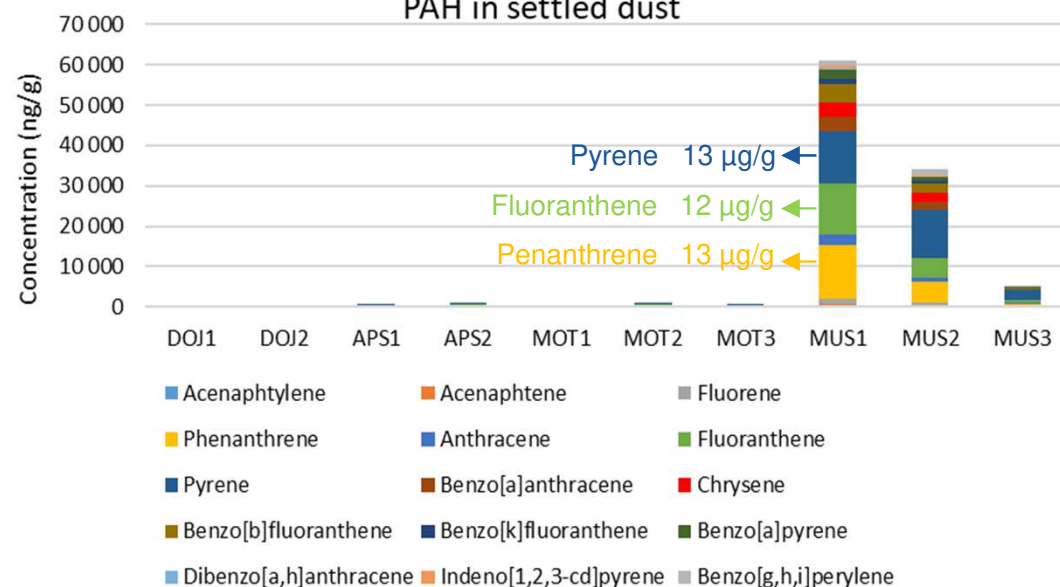
5. SVOC RESULTS IN AIR AND SETTLED DUST

10

PAH in air

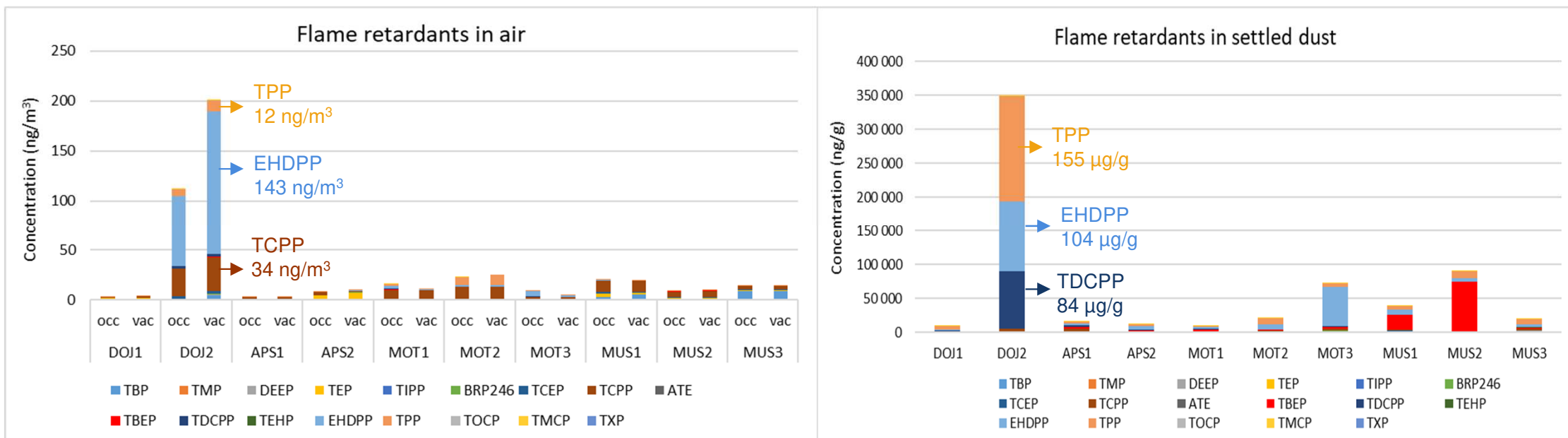


PAH in settled dust



- PAH are identified especially in air and settled dust in 2 sports halls MUS1 and MUS2
- **Fluorene** and **phenanthrene** are the most present in air
- **Phenanthrene**, **fluoranthene** and **pyrene** are the most present in settled dust

5. SVOC RESULTS IN AIR AND SETTLED DUST

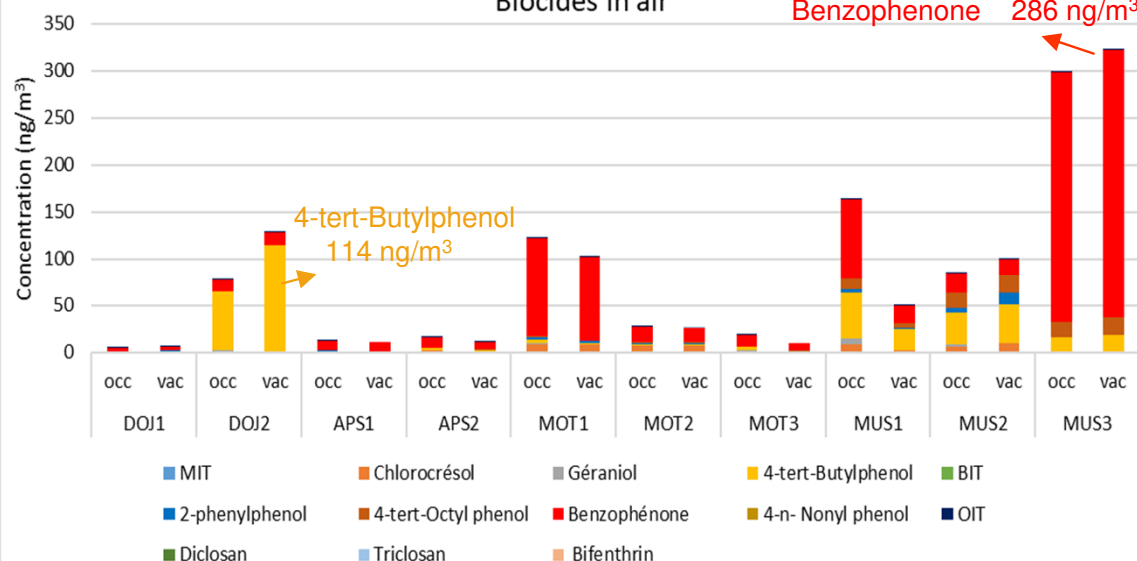


- OPFRs are identified especially in air and settled dust in DOJ2
- **TCPP, EHDPP** and **TPP** are the most present in air in DOJ2
- **TDCPP, EHDPP** and **TPP** are the most present in settled dust in DOJ2
- **TBEP** is the most present in settled dust in MUS1 and MUS2

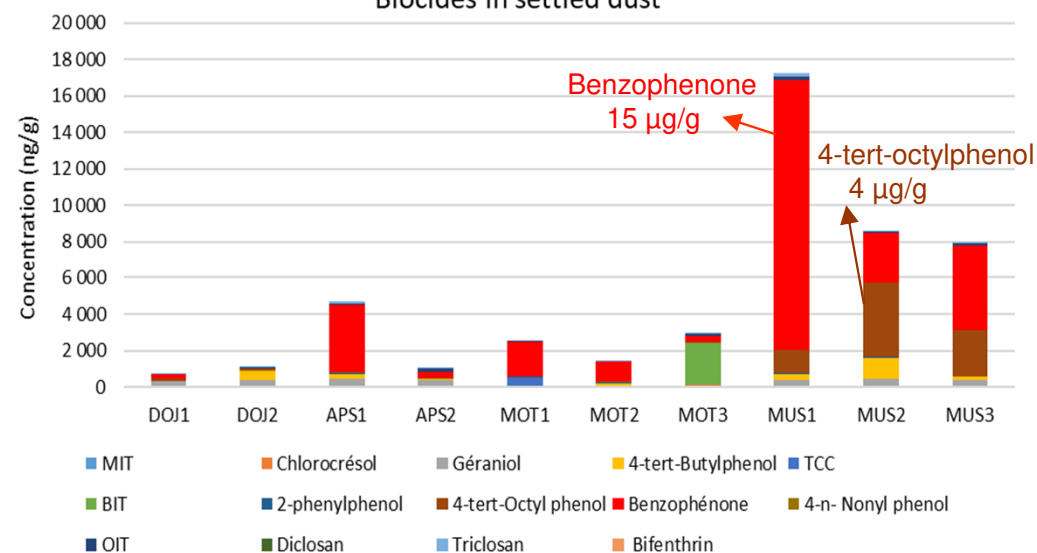
5. SVOC RESULTS IN AIR AND SETTLED DUST

12

Biocides in air

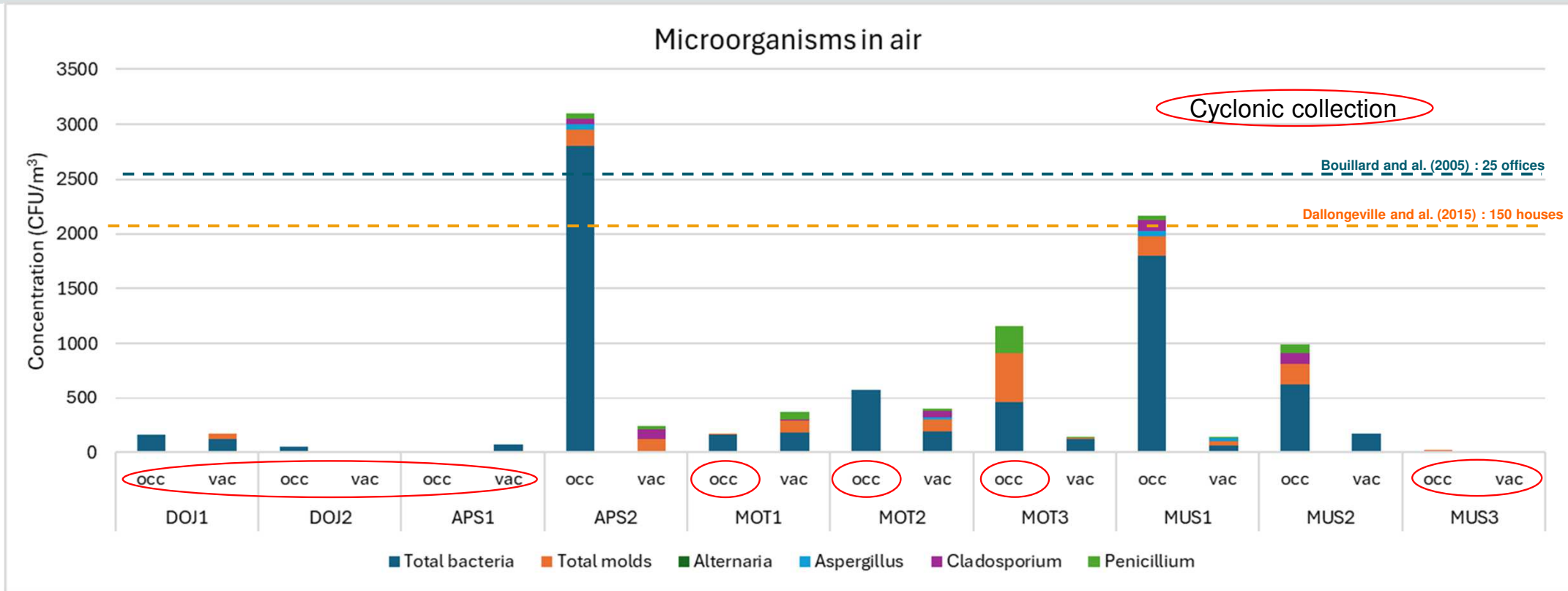
Benzophenone 286 ng/m³4-tert-Butylphenol
114 ng/m³

Biocides in settled dust

Benzophenone
15 µg/g4-tert-octylphenol
4 µg/g

- **4-tert-butylphenol** and **benzophenone** are identified especially in air
- Biocides are mainly present in the settled dust in the 3 fitness centers (MUS)
- **Benzophenone** and **4-tert-octylphenol** are identified especially in settled dust

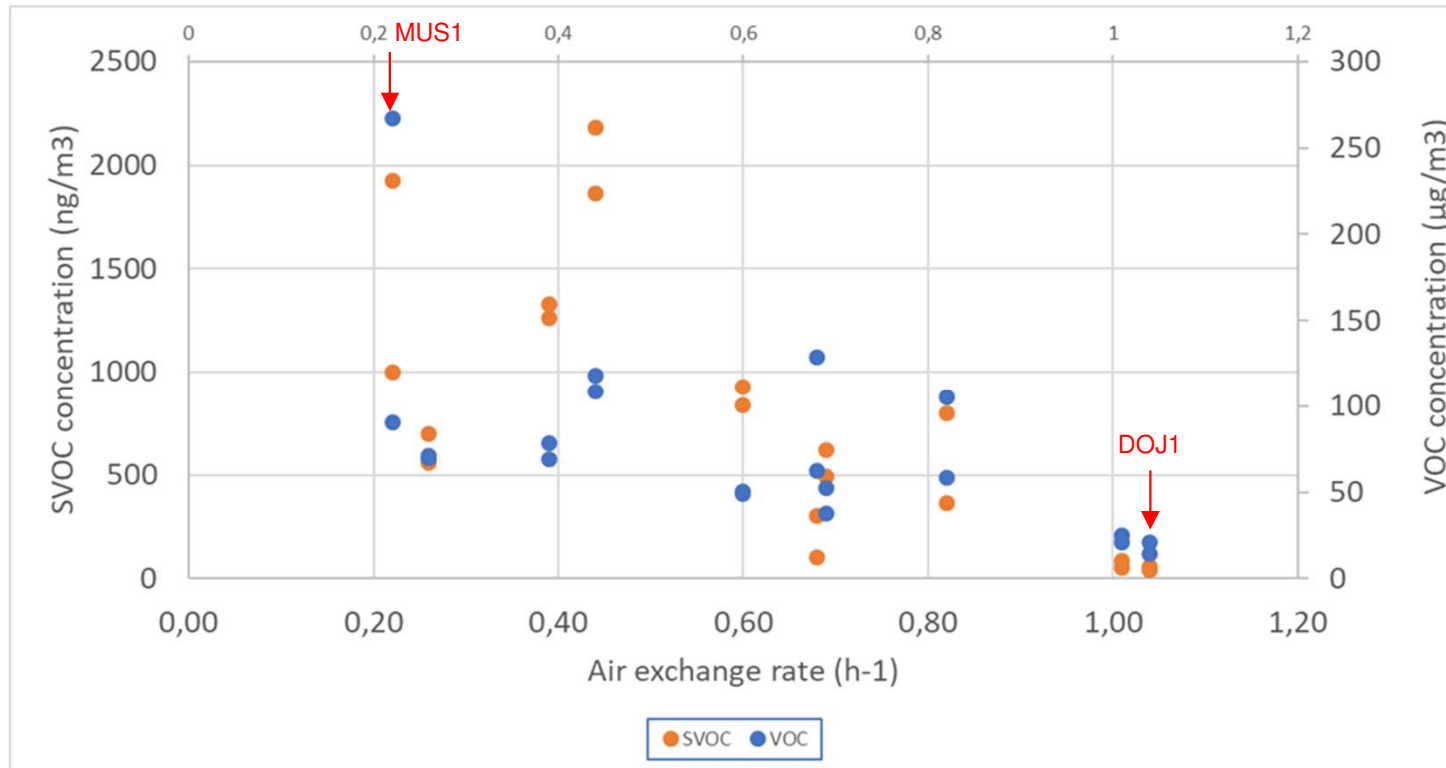
6. MICROORGANISMS RESULTS IN AIR



- Microbiological contamination in the range of residential ones
- Bacterial contamination : higher in occupied conditions (brought by occupants : identification of *Micrococcus* and *Staphylococcus*)
- Mold contamination : fairly low - mold species often detected in indoor environments
- **SARS-COV-2 not detected (< 160 UG/m³)**

7. IMPACT OF VENTILATION

14



- Positive impact of ventilation on VOCs and SVOCs concentrations in air
Key role of air exchange rate in managing indoor air quality
- DOJ1 and APS1 (recent building : 2016/low emission materials/dual flow ventilation) are the less contaminated sports halls

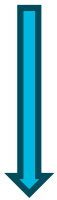
8. CONCLUSION

- **New knowledge on IAQ in sports facilities :**
more than hundred VOC and SVOC identified and quantified as well as several microbiological contaminants in indoor air and settled dust
- **VOC and SVOC concentrations** in air follow the same trend : vary greatly depending on typologies, years of construction, choice of materials or cleaning products and air renewal.
- **New sports halls :** very low concentrations levels, positive impact of materials choice and efficient ventilation on IAQ
- Some pollutants (**phthalates**) with high concentrations levels need to be further investigated to see if they pose a problem in terms of public health
- Non-target substances also need further attention and a better characterization as potential substances of concern
- **Microorganisms concentrations** in studied sports halls is rather low. SARS-CoV-2 was not detected (detection of this virus in air is difficult in lightly contaminated spaces)

9. PERSPECTIVES

Continuation of the study on a selection of **3 sports halls** :

- **DOJ2** (Dojo) : higher emitting materials than DOJ1
- **MOT2** (Motricity room) : higher concentrations of chemical and microbiological pollutants than in the other 2 motricity rooms
- **MUS 1** (fitness center) : diversity of SVOC (phthalates, PAH, flame retardants) – higher bacteria level



Identification of
contaminants sources



Contaminants distribution
understanding in indoor
environments
(between air, surfaces, particles)



Exposure evaluation,
Information on
routes of exposure



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et de physico-chimie
pour l'environnement et les matériaux



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THANK'S FOR YOUR ATTENTION !

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