



Experimental evaluation of the Demand-controlled positive input ventilation VMI in a nursery

- Feedback -



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Air4Kids project

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VMI system

**Guarantee a good
indoor air quality**

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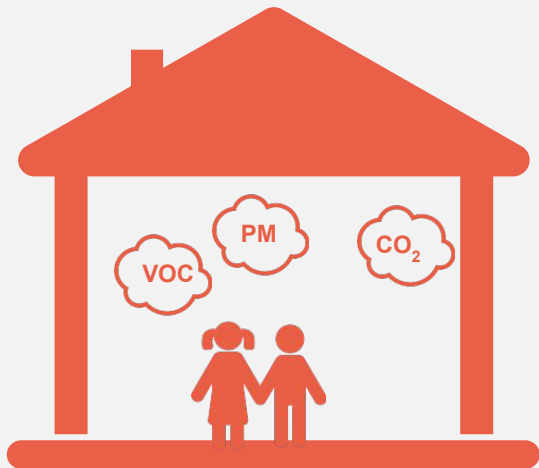
Conclusion

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Perspective

CONTEXT

Effect of air pollution on children



Indoor air is **2 to 10 times** more polluted than outdoors



In cities, children can spend more than **8 hours** per day in daycare (CnAF*)



Air pollution is one of the leading threats to child health, accounting for almost **1/10 deaths** in children under five years of age. (WHO**)

Infants and toddlers are **more exposed and vulnerable** than adults due to their physiology, inability to articulate discomfort and to adapt their behaviour.



Damage children's central nervous system

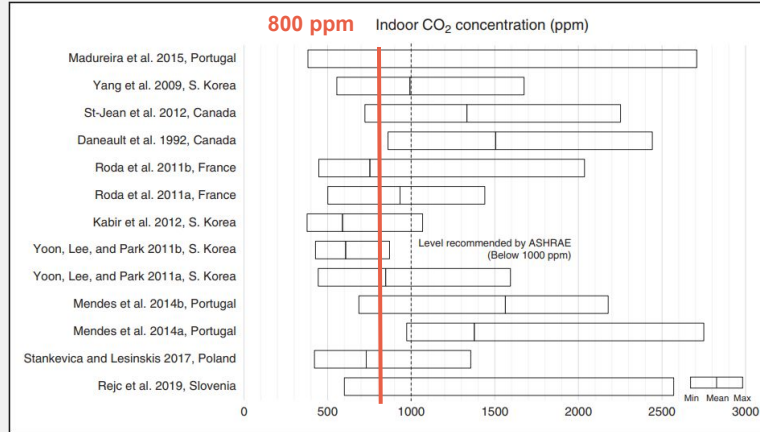


Contribute to the development of childhood asthma

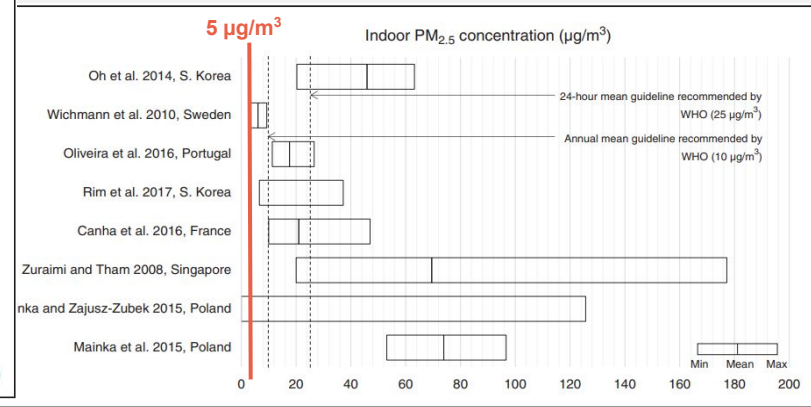
CONTEXT

Indoor air pollution in nurseries

HCSP: COVID-19 recommendations Apr 2021



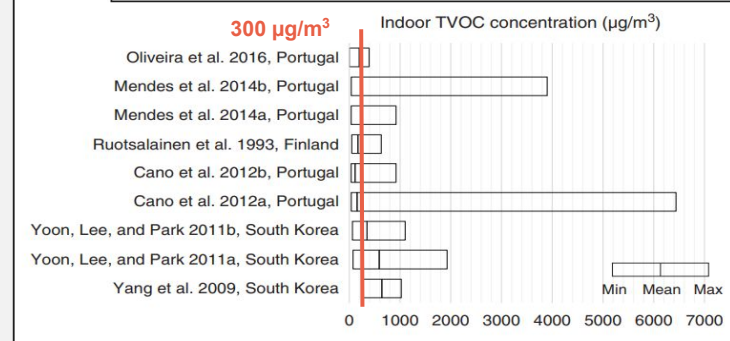
WHO: Air quality guidelines sep 2021



- Poor ventilation
- High outdoor particulate pollution
- Indoor sources



Poor or inadequate ventilation contributes to viruses transmission



Commission of the European Communities (CEC 1992)

Source : Building Serv. Eng. Res. Technol. 2021, Vol. 42(5) 603–632

AIR4KIDS

Improving Air Quality

Air4kids is one of the 10 winning innovative projects of the “**Air Quality**” **experimentation program** launched in 2017 by Paris&Co’s Urban Lab, City of Paris and Airparif’s Airlab

Objectives

- Improve air quality in Early Childhood and Education Care Establishments (ECEC) through the installation of a **demand-controlled** positive-input mechanical ventilation system (VMI®)
- Monitor and inform about air quality in real time
- Demonstrate the value and performance of VMI®, mainly used in the residential sector, to meet the indoor air guideline values in ECEC.



Installed the VMI system in two nurseries: **Verdun** and **Poulmarch**



The efficiency of the system was evaluated with the help of **OFIS** and **Air Expertise Cluster** of VEOLIA

VMI®

Positive input ventilation

Positive-Input demand controlled ventilation , VMI® :



- **Flow rate continuously adapting :**
 - Continuous measurement of the IAQ by micro-sensors
 - Variable airflow rate based on indoor and outdoor RH and indoor CO₂ concentration
- Maximum design airflow rate 1000 m³/h
- **Outside air is filtered using ePM 1 55% filter**
- Fresh air is preheated for better comfort.
 - Electrical resistance
 - Hydraulic heat exchanger connected to the main heating system network
- **Lightweight, easy to handle and install**
- VMI® system creates a slight overpressure inside the room : exhaust air is rejected through the passive vent
- Modbus communication (included)
- **Compatible with fire regulations**

EXPERIMENT Test Protocol

The test protocol is identical in the both nurseries and in all the studied zones



Installing the IAQ monitoring devices
(CO₂, RH, T, TVOC, PM)



Punctual IAQ audit held by Veolia using precision measurement instruments
(CO₂, CO, TVOC, RH, T, PM, biological contaminants, Benzene and Formaldehyde)

Before and after the installation of the ventilation system



Installing the VMI® system in one section in each nursery

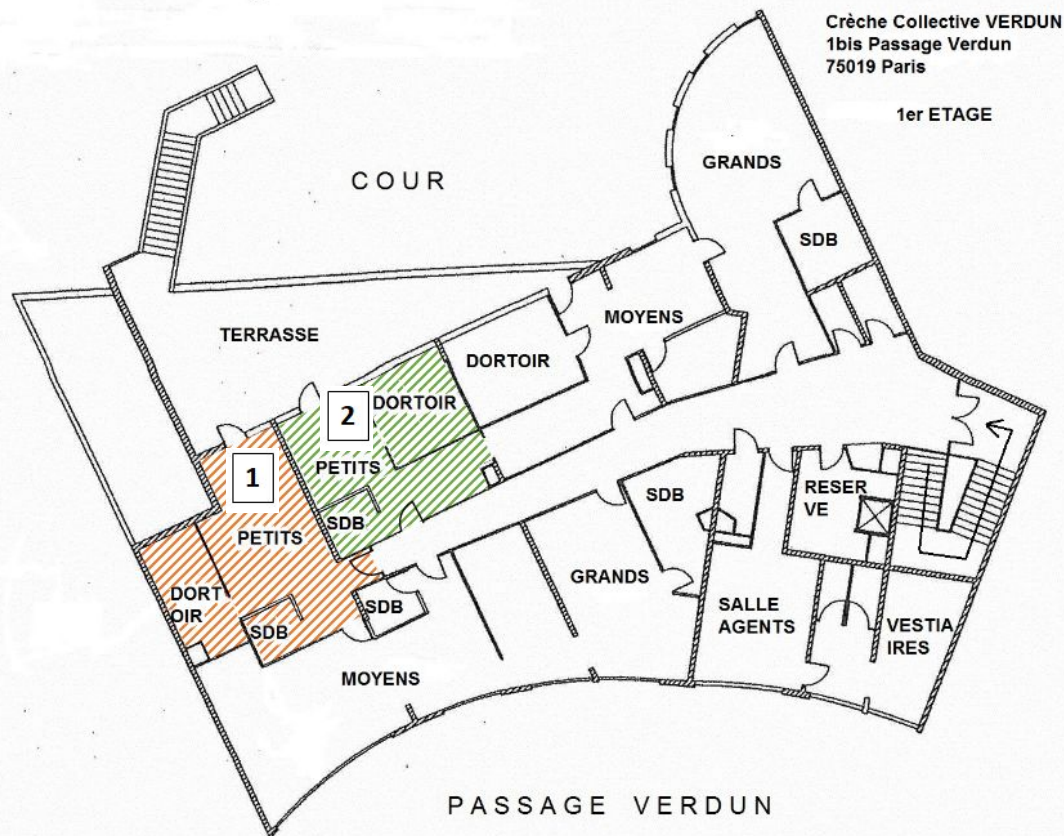


Following up the occupancy and the activities using surveys and direct communication (mail & phone)










EXPERIMENT Installation

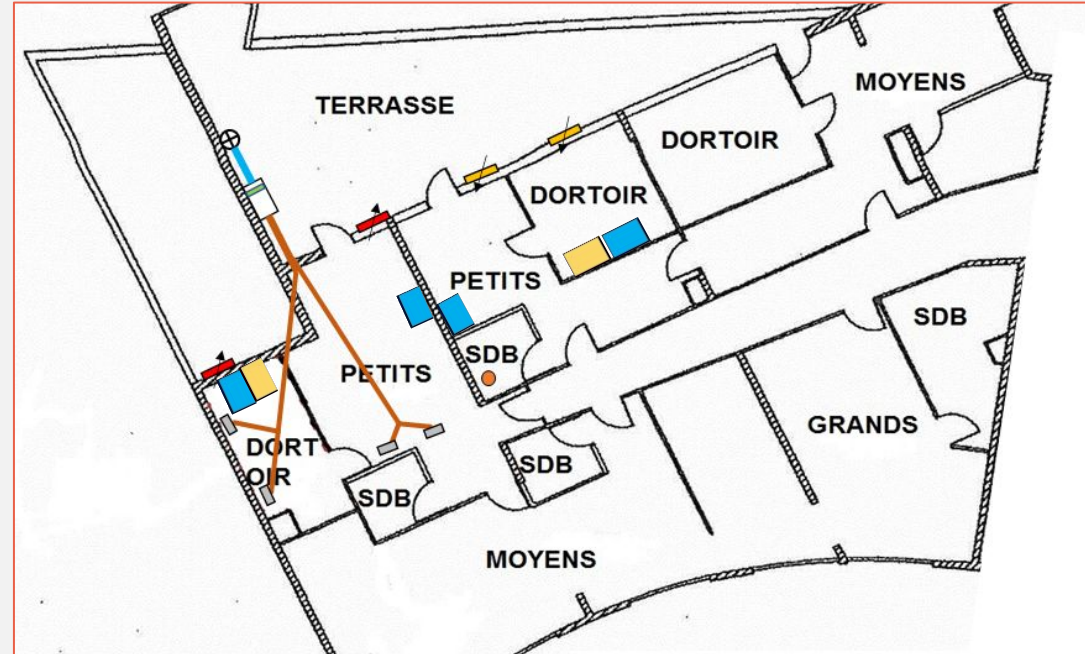
Area 1 with VMI®

Area 2 without VMI®



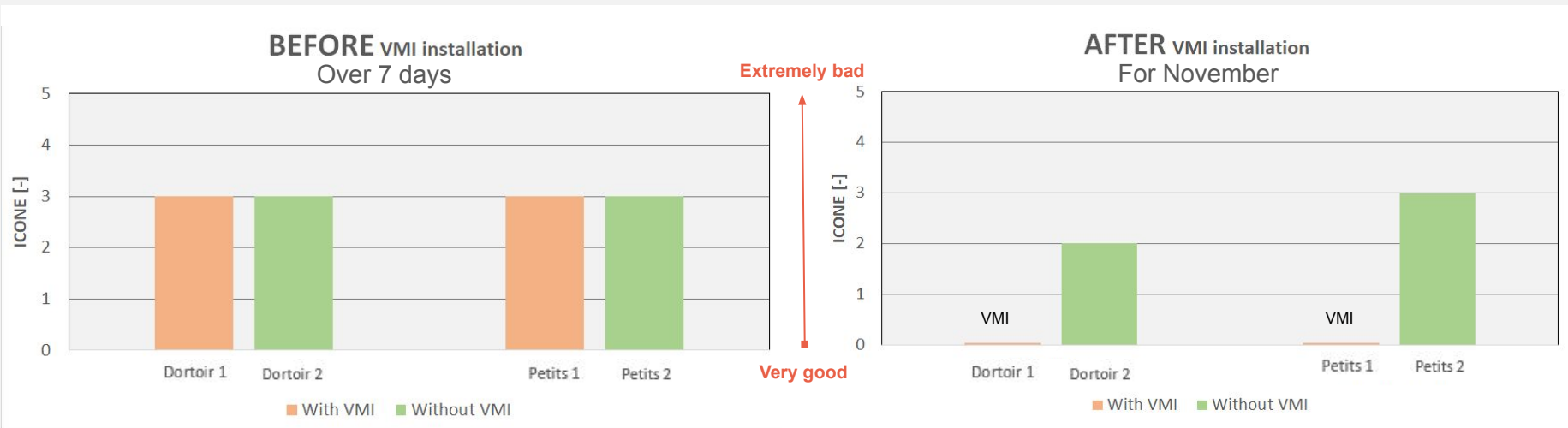
EXPERIMENT Installation

-  E4000 NG (VOCT / CO₂ / T / RH)
-  P4000 (PM1 / PM2.5 / PM10)
-  Duct ø200 mm
-  VMI®
-  Duct ø160 mm
-  Duct ø125 mm
-  Supply vent ø125
-  Intake air from outdoor ø160 mm
-  Passive air entrance
-  Existing mechanical ventilation



RESULTS

Impact on CO₂



Compilation using ICONE index

$$ICONE = 2,5/(\log(2)) \log(1+f_1+3f_2)$$

f_1 = exposition frequency 1000 - 1700 ppmv

f_2 = exposition frequency >1700 ppmv

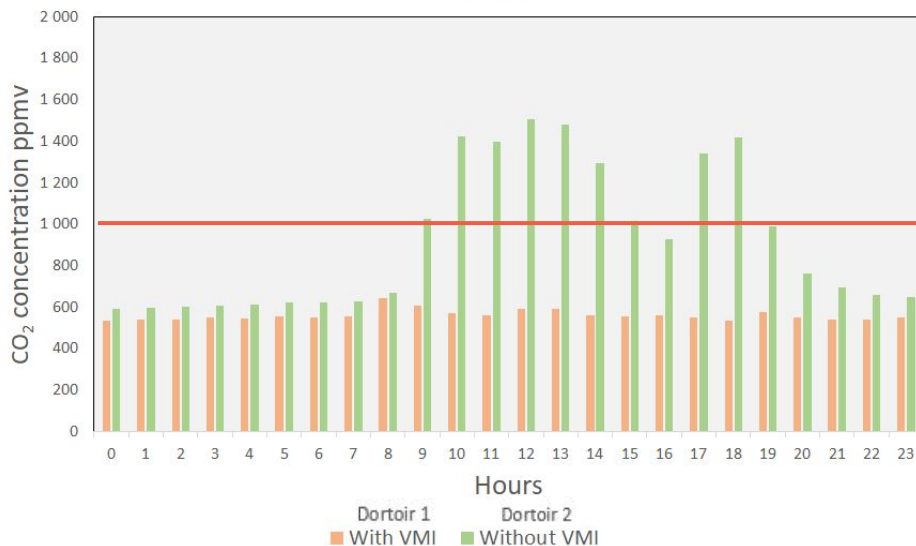
RESULTS

Impact on CO₂

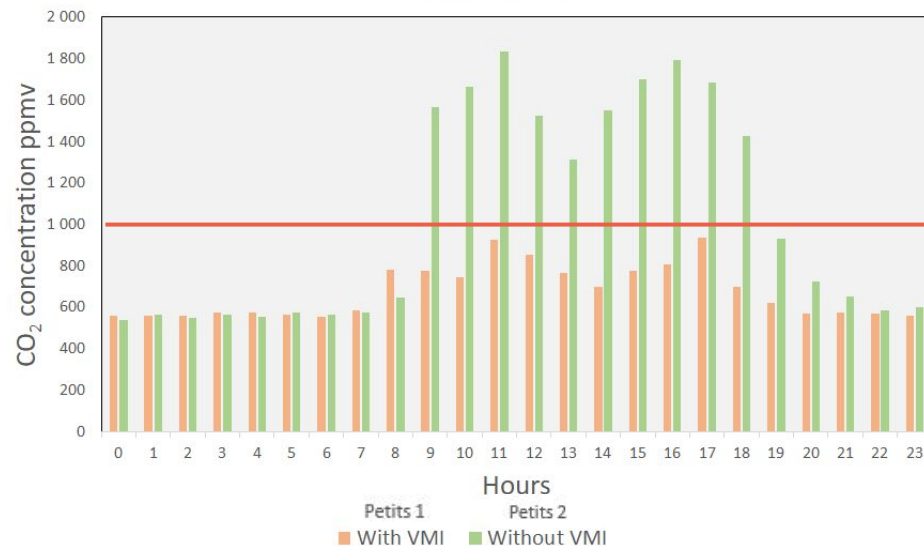
Zoom over one day

Room with mechanical ventilation : [CO₂] ≤ 1000 ppmv

Dormitory



Awakening room

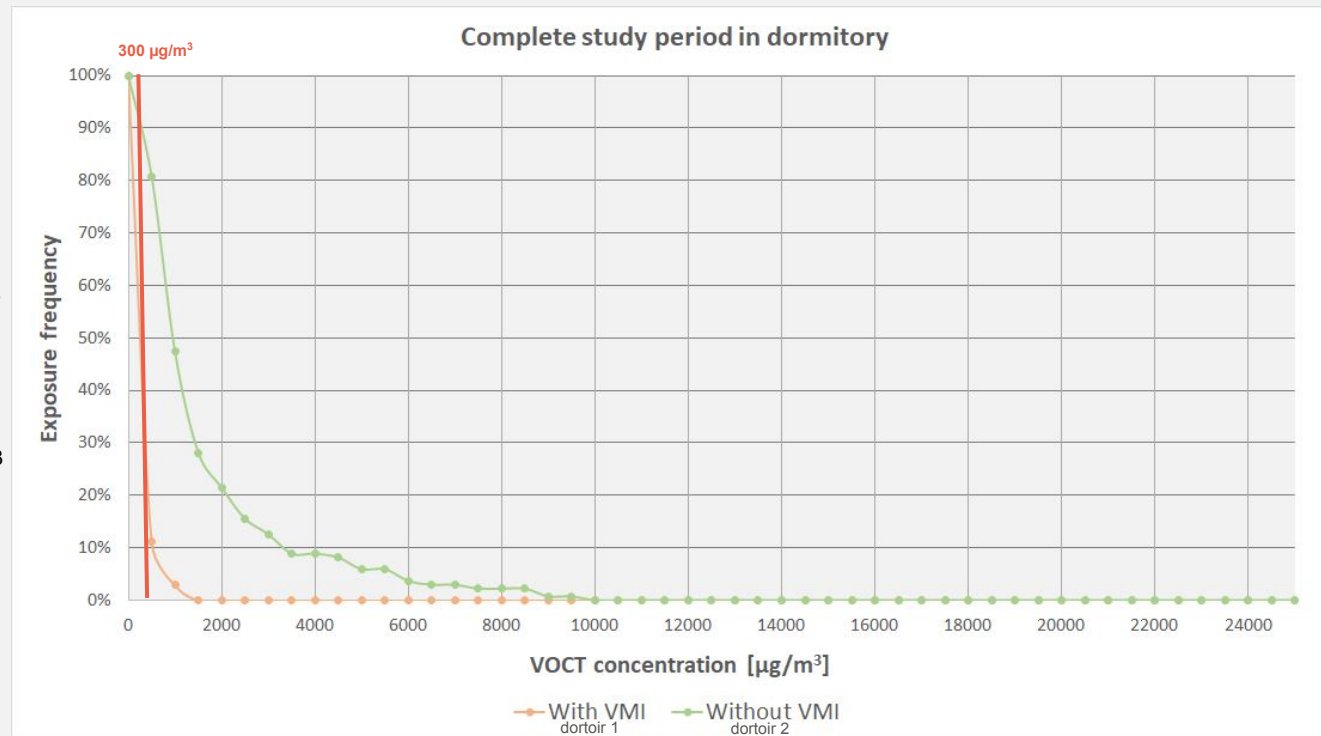


RESULTS

Impact on TVOC

Room with Positive Input Ventilation:
85% of time, TVOC level < 300 $\mu\text{g}/\text{m}^3$

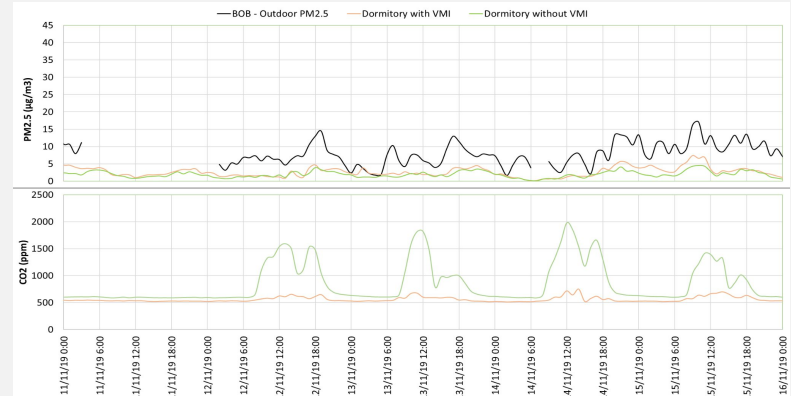
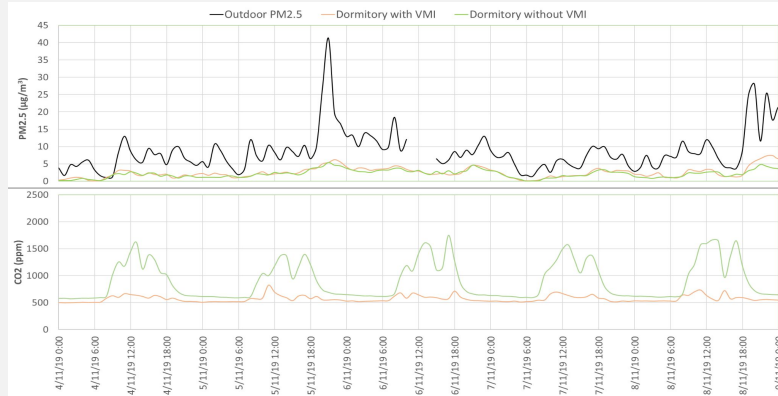
Room with existing mechanical
 ventilation:
15% of time, TVOC level < 300 $\mu\text{g}/\text{m}^3$



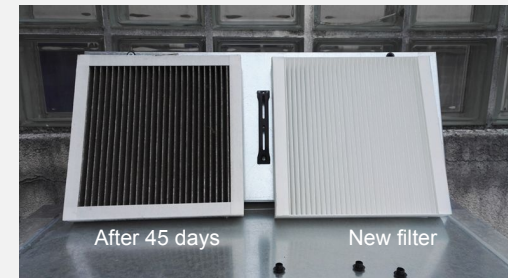
RESULTS

Impact on PM2.5

Zoom on working days in the first 2 weeks of November

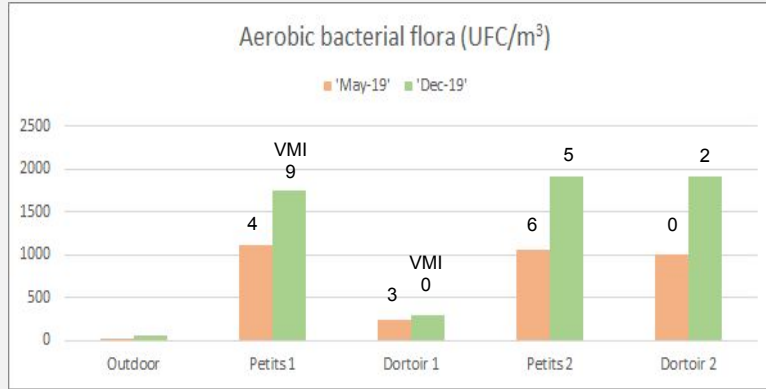


Room with Positive Input Ventilation:
 Lower CO2 concentration \Rightarrow higher air change rate
 However PM2.5 concentration is the same \Rightarrow Good filtration



RESULTS

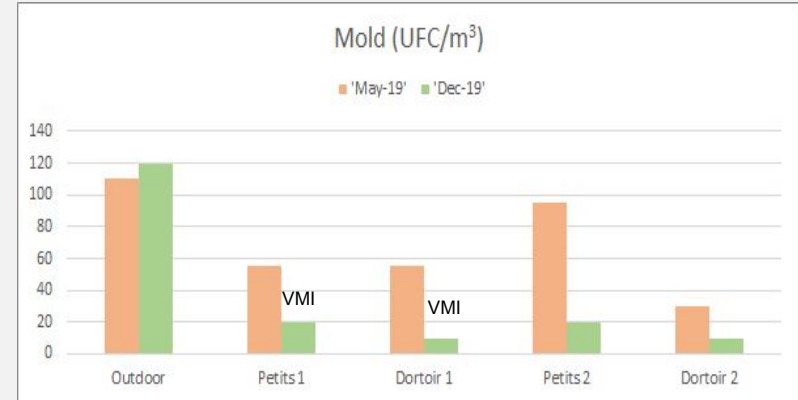
IAQ audits - Verdun



- Though a higher ventilation rate in the section with a mechanical air supply, we observe same level of mold as for the other section with much lower ventilation rate
⇒ **impact of air filtration**

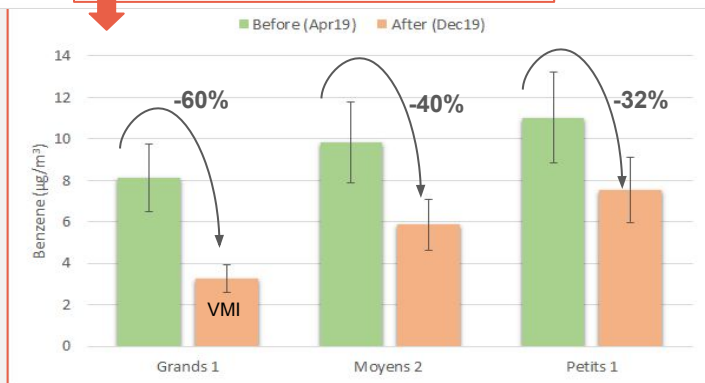
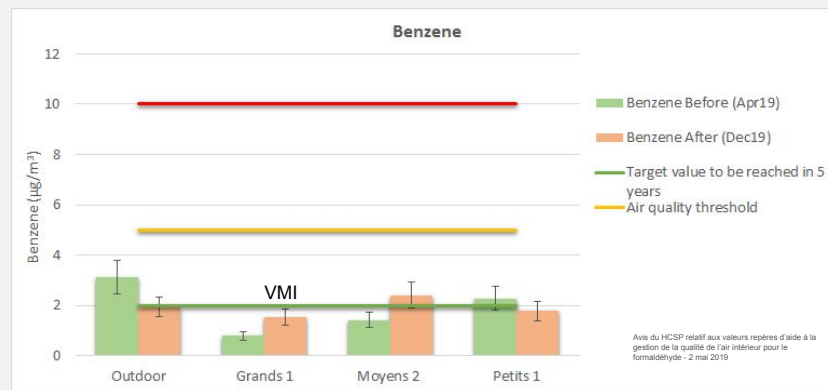
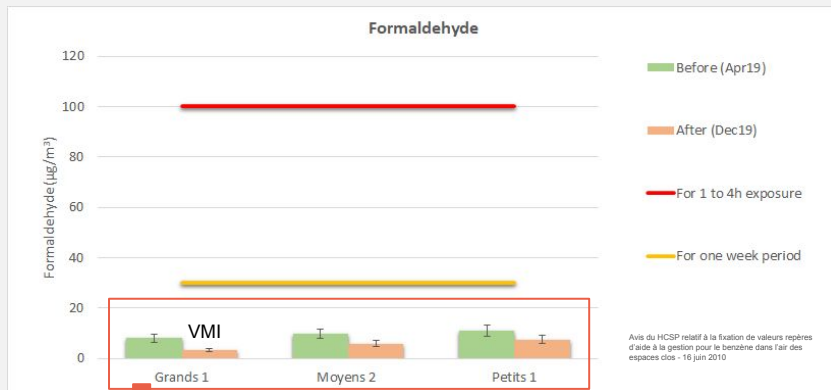
- Though a higher occupancy (almost double) in the awakening room with a mechanical air supply, we observed same level of aerobic bacterial flora as in the other awakening room

⇒ **Impact of a higher ventilation rate**



RESULTS

IAQ audits - Poulmarch

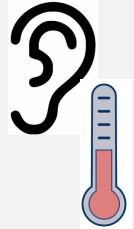
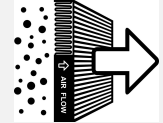


- Formaldehyde and Benzene levels are under recommended values
- An additional positive impact of the VMI was noticed in the Grands 1

CONCLUSION

Sum-up

- The use of the **the positive input ventilation VMI** as a **Demand-Control ventilation DCV** guarantees a CO_2 level under the recommended threshold.
- The TVOC concentration is diluted due to **direct supply of outdoor air** in living space
- Outdoor **air filtration** is essential to limit the introduction of fine particles
- The **continuous monitoring** of multiple parameters helps to evaluate the efficiency of the system to deal with other pollutants than the CO_2
- The **IAQ punctual audits** are complementary to the continuous monitoring and mandatory to assess the performance on specific pollutants (biological and chemical contaminants)
- **Occupant feedback** and a good communication with occupants helps improve the system to respond to their needs (thermal and acoustic comfort)



PERSPECTIVE

Improving experiment setup

- Outside air quality sensors added
- Windows/doors sensor added
- Continuous monitoring
- IAQ audits : formaldehyde + benzene
 - ◆ Summer VMI ON/OFF
 - ◆ Winter VMI ON/OFF
- Sensors inter-comparison



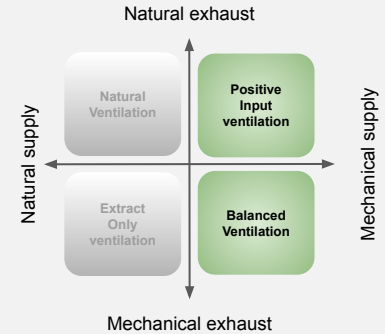
Jean Marie Poulmarch nursery

PERSPECTIVE

Improving installation

For a large scale deployment

Standardisation of the installation of different type of ventilation system in small buildings



Simple



Fast



Reproducible



Economic

Thank you for your attention

Q&A

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