AIR TREATMENT FOR THE COMFORT OF TERTIARY BUILDING USERS

CUBAIR Project

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Cerema

IMT Atlantique
Bretagne-Pays de la Loire
École Mines-Télécom

UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR
LABORATOIRE de THERMIQUE ÉNERGÉTIQUE et PROCÉDÉS
LaTEP/ EA 1932

air Sûr
L'air de rien, l'air c'est tout

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

What is Cerema ?

Centre for Studies and Expertise on Risks, Mobility, Land Planning and the Environment

- A State agency of **scientific** and **technical expertise**, in support of the definition, implementation and evaluation of public policies, on both national and local levels

- Under the supervision of the French ministries in charge of sustainable development, town planning and transportation

General context

- We spend 80 % of our time in indoor atmosphere
- Specially at the work ≈ 8 hours per day
- Ventilation networks in tertiary buildings use outdoor air
- Or for tertiary buildings located in urban areas, air is characterised by high concentrations of specific pollutants namely NO_X, PM or BTEX
- In urban areas, air treatment need to be considered

CUBAIR Project

- Project Call – ADEME « Responsible Buildings to the 2020 horizon »

- 4 partners : Cerema, IMT Atlantique Bretagne-Pays de la Loire École Mines-Télécom, Université de Pau et des Pays de l'Adour – Laboratoire de Thermique Énergétique et Procédés, Air Sûr

- Design and characterise an air treatment prototype with adsorption, filtration and photocatalysis techniques to improve indoor air quality

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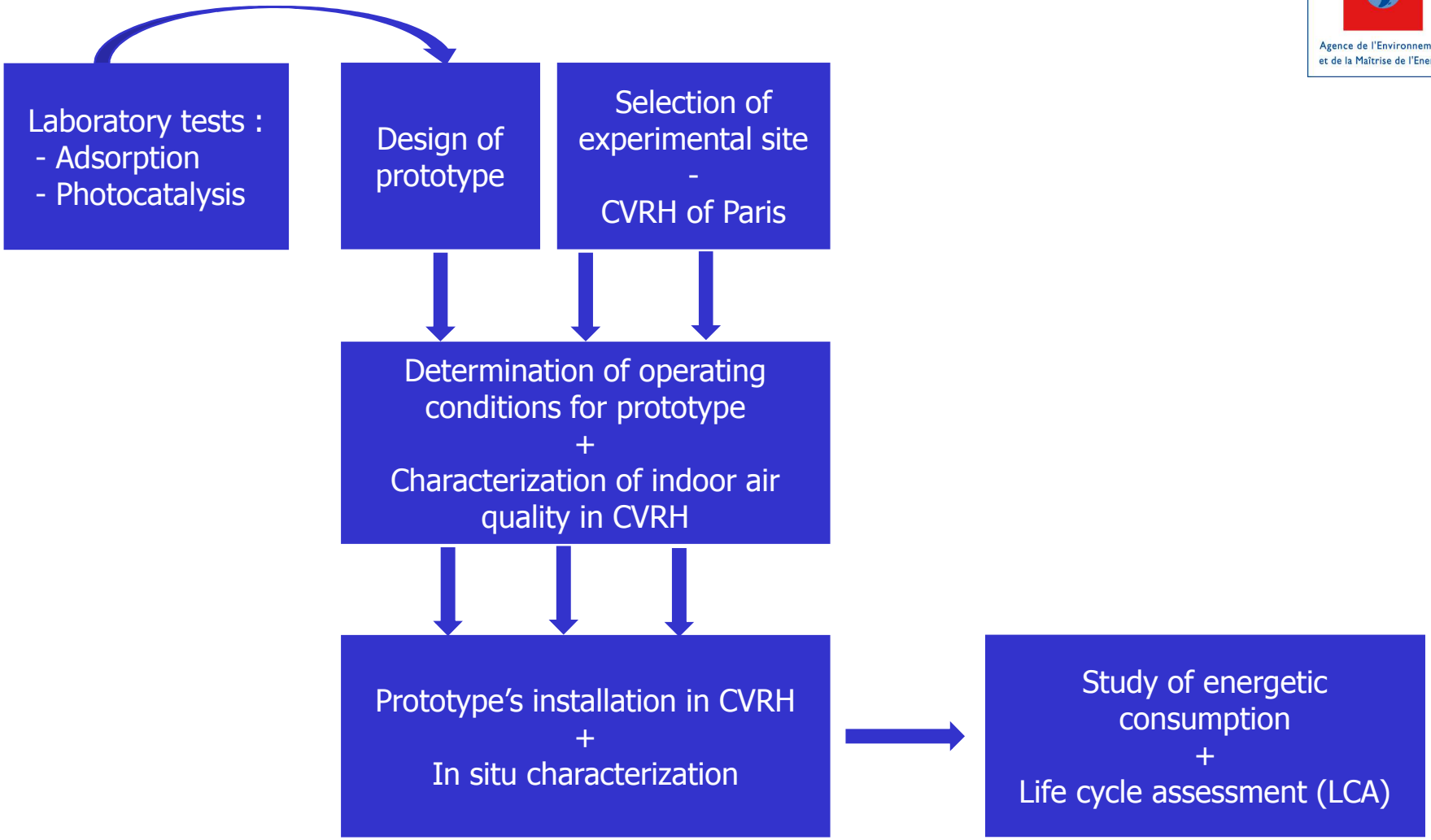

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Laboratory tests :
- Filtration
- Photocatalysis

Design of prototype

Selection of experimental site
-
CVRH of Paris

Determination of operating conditions for prototype
+
Characterization of indoor air quality in CVRH

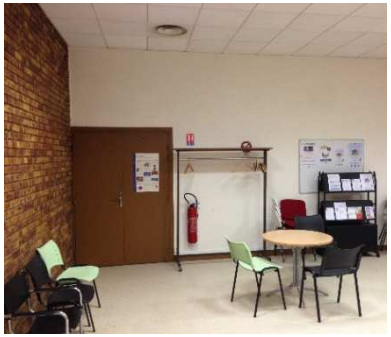
Prototype's installation in CVRH
+
In situ characterization

Study of energetic consumption
+
Life cycle assessment (LCA)

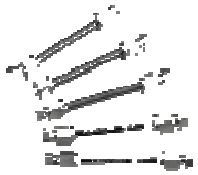
Selected site – CVRH of Paris

- Paris 13th district
- Next to the Paris ring road and the Massena Boulevard

- Experimentation took place in the cafeteria at the ground floor



Characterization of CVRH indoor air quality



- Gaseous and particulate pollutants :

Parameters	Sampling Method	Detection or analyse method	Time step	Measurement period	Location
NO_X (=NO + NO_2)	Continuous measurements : HORIBA, APNA-370	Chemoluminescence	5 minutes	May 2016 to March 2017	* Indoor * Ventilation pipe * Outdoor
PM (PM_1, $PM_{2,5}$, PM_{10})	3-stage cascade impactor DEKATI	Gravimetric measurements	2 weeks	May 2016 to March 2017	* Indoor
Ozone (O_3)	Continuous measurements : HORIBA, APOA-370	UV-Absorption	5 minutes	May 2016 to March 2017	* Indoor
Formaldehyde	Profil'Air ETHERA cartridges	Colorimetric method Opacity measurements	20 minutes	03/08/2017 05/17/2017	* Indoor
VOC (Volatile Organic Compounds)	Active sampling on 3-adsorbant cartridges	TD-GC/MS	1 week	October 2016	* Indoor
	Diffusive sampling on Radiello® cartridges	TD-GC/MS	4,5 days	09/16 : from 12 to 16	* Indoor
Oxygenated compounds : aldehydes and acetone	Active sampling on 2,4-DNPH cartridges	HPLC-UV	6 h	05/31/16	* Indoor
	Diffusive sampling on 2,4-DNPH cartridges	HPLC-UV	4,5 days	From 05/30 to 06/03/16	

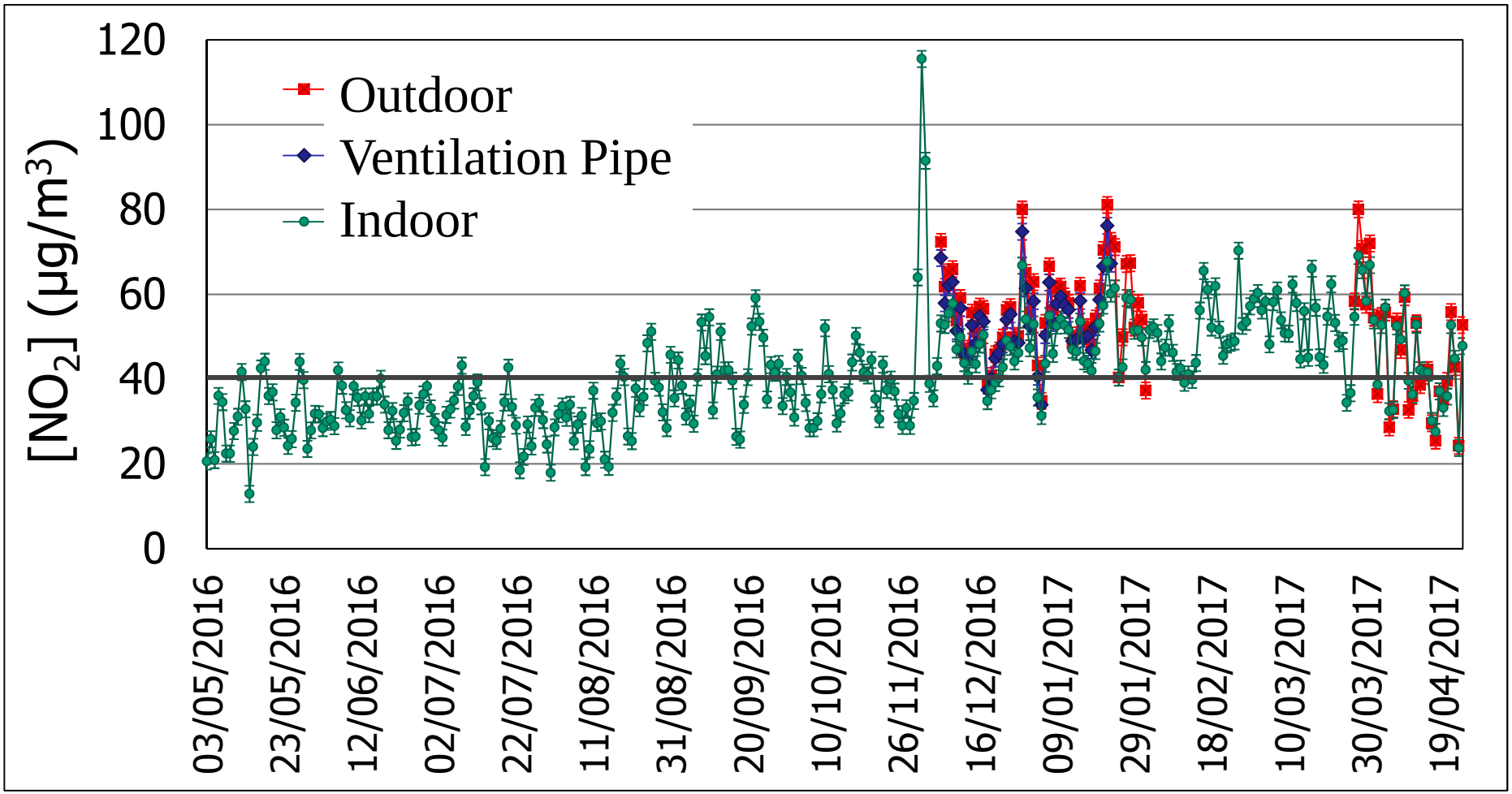
Characterization of CVRH indoor air quality

- Biological and comfort parameters : punctual field campaigns

Parameters	Sampling Method	Detection or analyse method	Time step	Location
Revivable bacteria	Active sampling thanks to a cyclonic sampler in liquid (300 L/min)	Sowing of 3-dilutions (duplicate) on a trypticase-soy agar medium and incubation for 48h at 37°C	3 times of 10 minutes sampling	* Indoor * Outdoor
Revivable mold		Sowing of 3-dilutions (duplicate) on a DG18 agar medium and incubation for 7 days at 25°C		
Endotoxins	Active sampling (2 L/min) on a glass filter membrane – NF EN 14031	Chromogenic kinetic LAL assay NF EN 14031	4 days	* Indoor
Comfort parameters (T, HR, CO_2)	Continuous measurements : Temperature : thermistor sensor – Relative Humidity : capacitive sensor – CO_2 : sensor with IR absorption detector		10 minutes	* Indoor

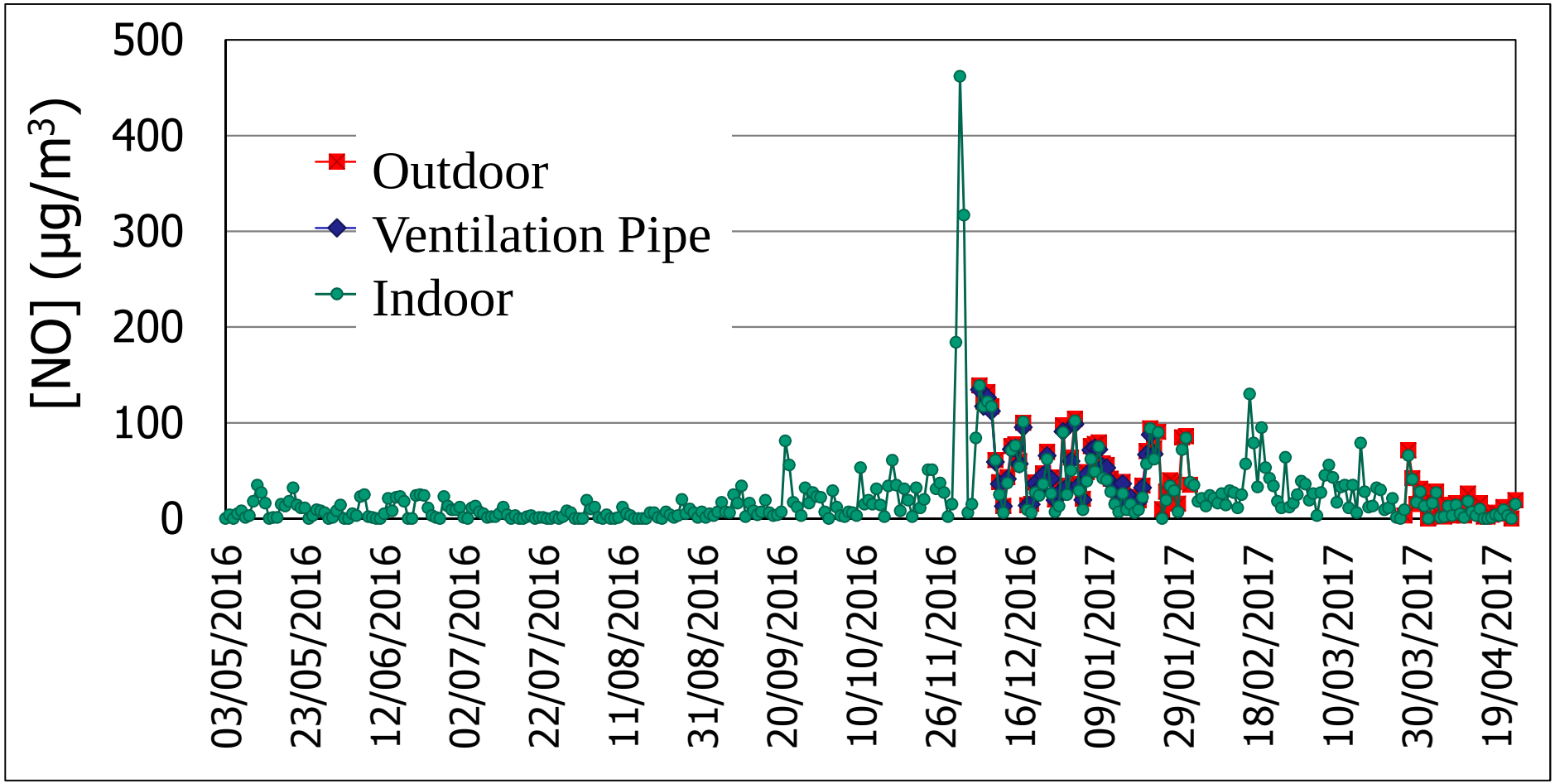
CVRH indoor air quality – Results

- Nitrogen oxides : indoor NO_2 mean : 41 µg/m^3



CVRH indoor air quality – Results

- Nitrogen oxides : indoor NO mean : 23 µg/m^3



CVRH indoor air quality – Results

- Nitrogen oxides :

comparison CVRH outdoor concentrations with Airparif stations

CVRH

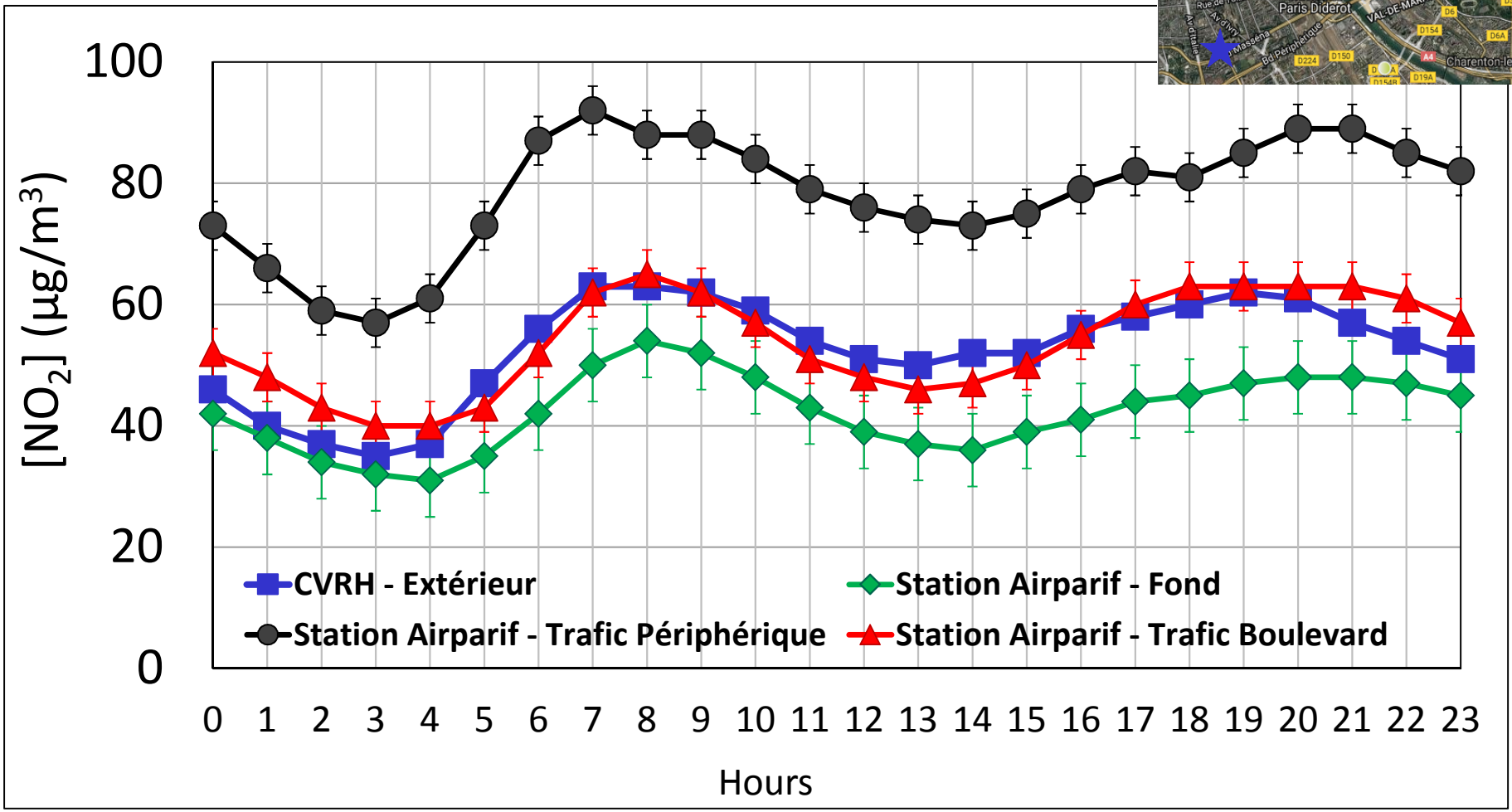
Airparif Station - Background

Airparif Station – Trafic/Boulevard

Airparif Station – Trafic/Ring Road

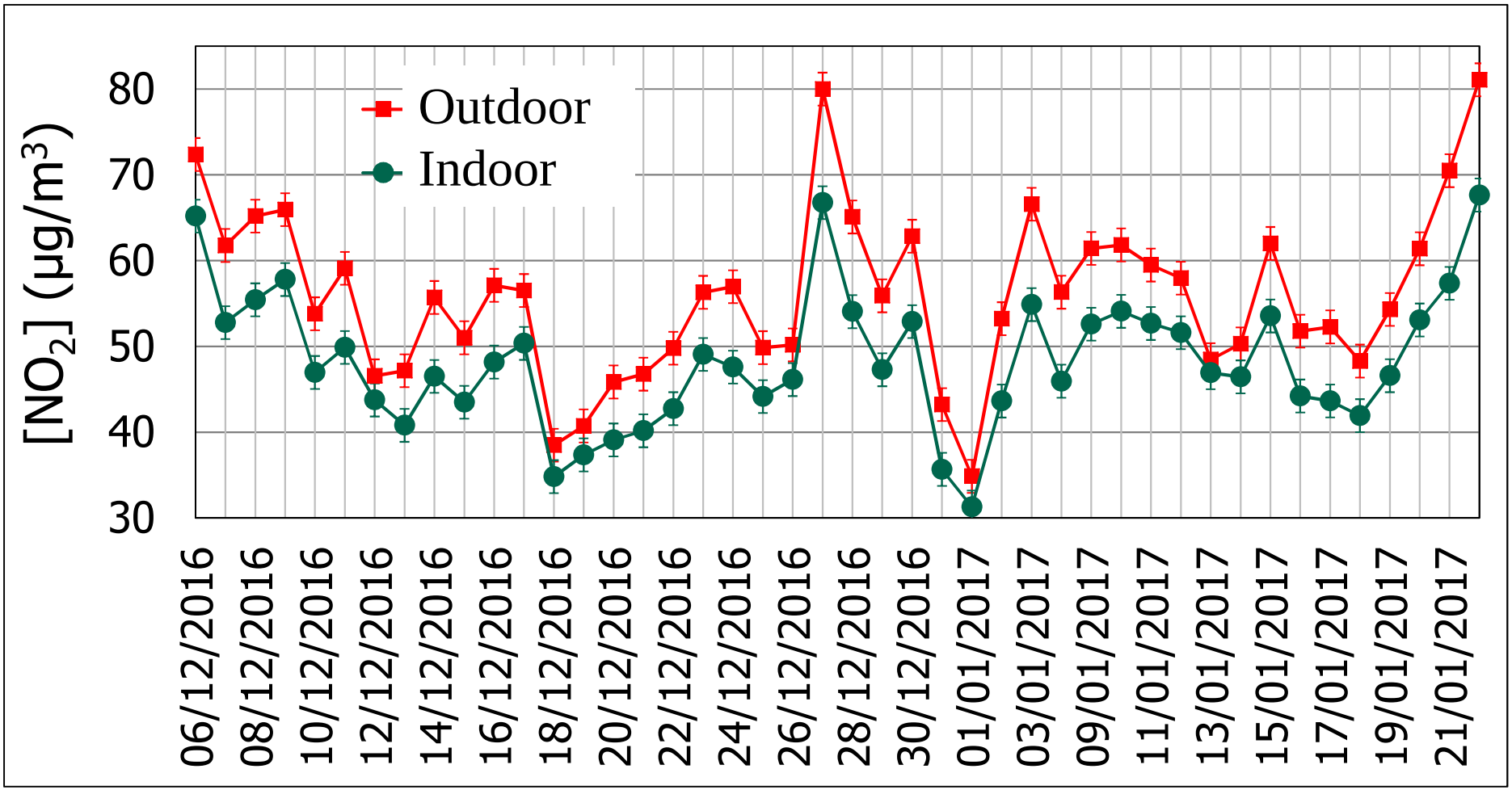
CVRH indoor air quality – Results

- Nitrogen oxides : comparison with Airparif stations



CVRH indoor air quality – Results

- Nitrogen oxides : transfer from outdoor to indoor air



CVRH indoor air quality – Results

Conclusions

- Transfer from outdoor to indoor (NO_X, PM)

- VOCs, biological and comfort parameters are standard for tertiary buildings equipped with air ventilation (OFFICAIR)

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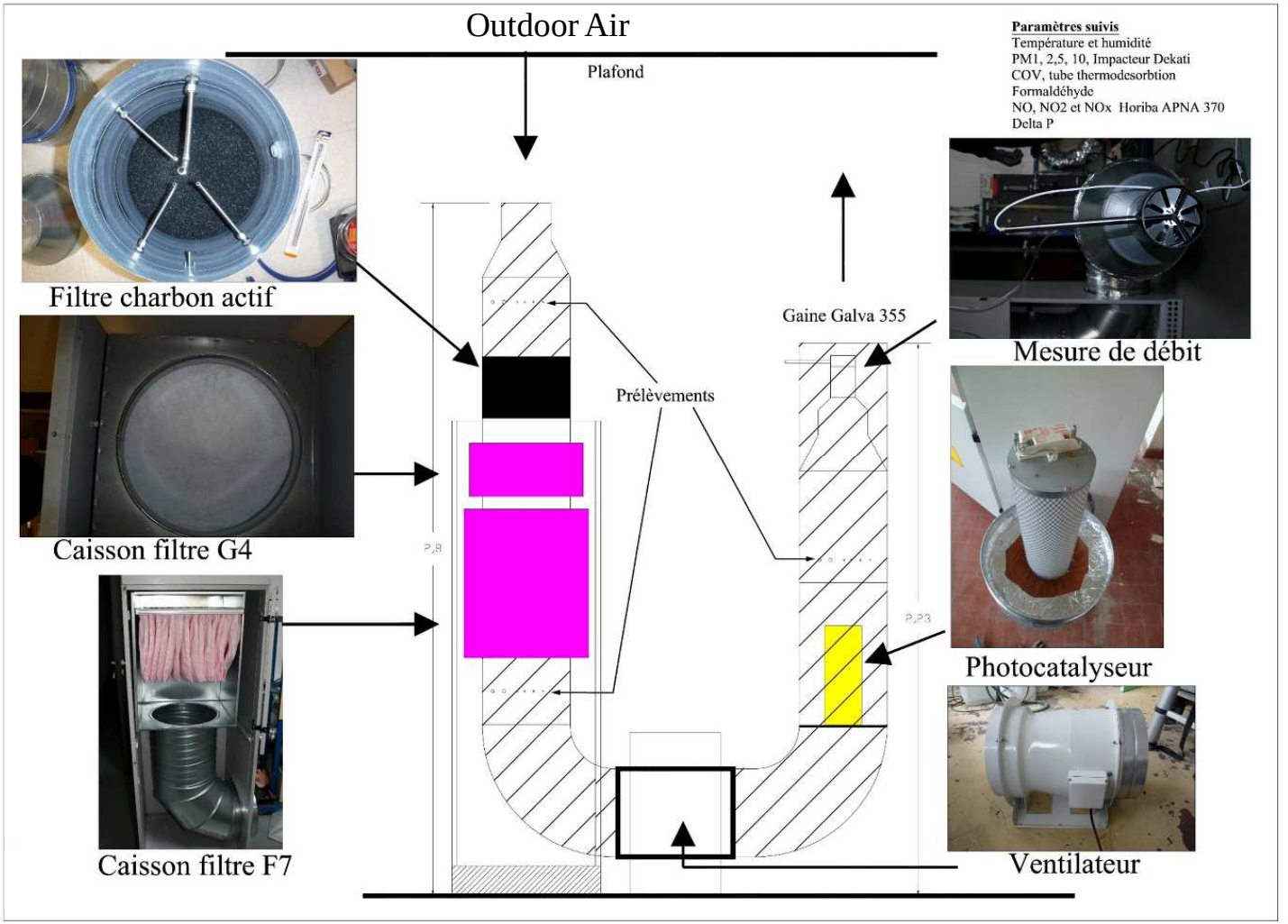
Design of prototype



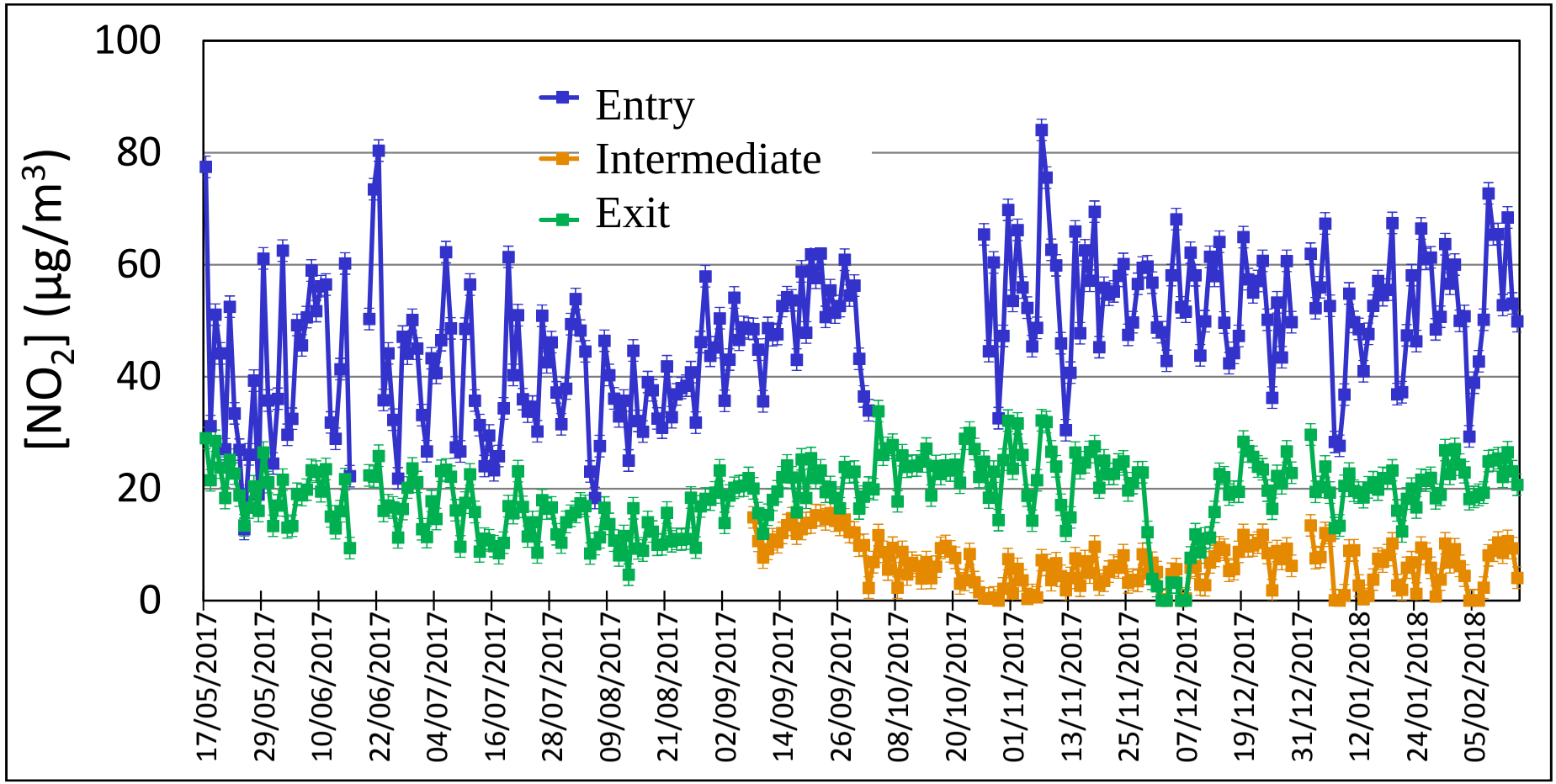
Materiel & Methods

- Characterization from March 2017 to March 2018
- 3 sampling points : entry, intermediate, exit of prototype

Parameters	Sampling Method	Detection or analyse method	Time step	Measurement period	Location
Flow, Temperature, Relative Humidity	KIMO sensors		1 minute	May 2017 to March 2018	3 sampling points
NO_x (=NO + NO_2)	Continuous measurements : HORIBA, APNA-370	Chemoluminescence	5 minutes	May 2017 to March 2018	3 sampling points
PM (PM_1, $PM_{2,5}$, PM_{10})	3-stage cascade impactor DEKATI	Gravimetric measurements	2 weeks	May 2017 to March 2018	3 sampling points
Ozone (O_3)	Continuous measurements : HORIBA, APOA-370	UV-Absorption	5 minutes	May 2017 to March 2018	Mobile sampling
VOC (Volatile Organic Compounds)	Active sampling on 3-adsorbant cartridges	TD-GC/MS	3/4 days	Different field campaigns	3 sampling points
Oxygenated compounds : aldehydes and acetone	Active sampling on 2,4-DNPH cartridges	HPLC-UV	6 h	January and March 2018	3 sampling points
Biological parameters	Impaction sampling (MAS 100) on a petri dish – Counting Charcoal Analysis		5 minutes (500 L) /	January 2018	Ambient air, Exit of prototype /

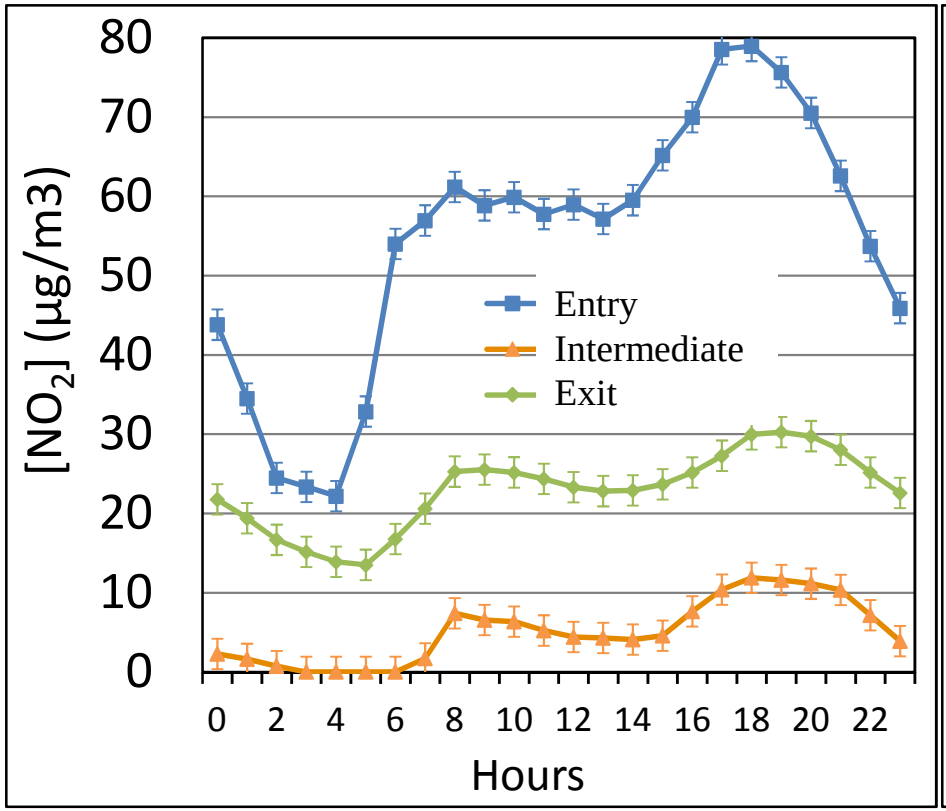
Prototype performances – Results

- Nitrogen oxides : NO_2



Prototype performances – Results

- Nitrogen oxides : NO_2



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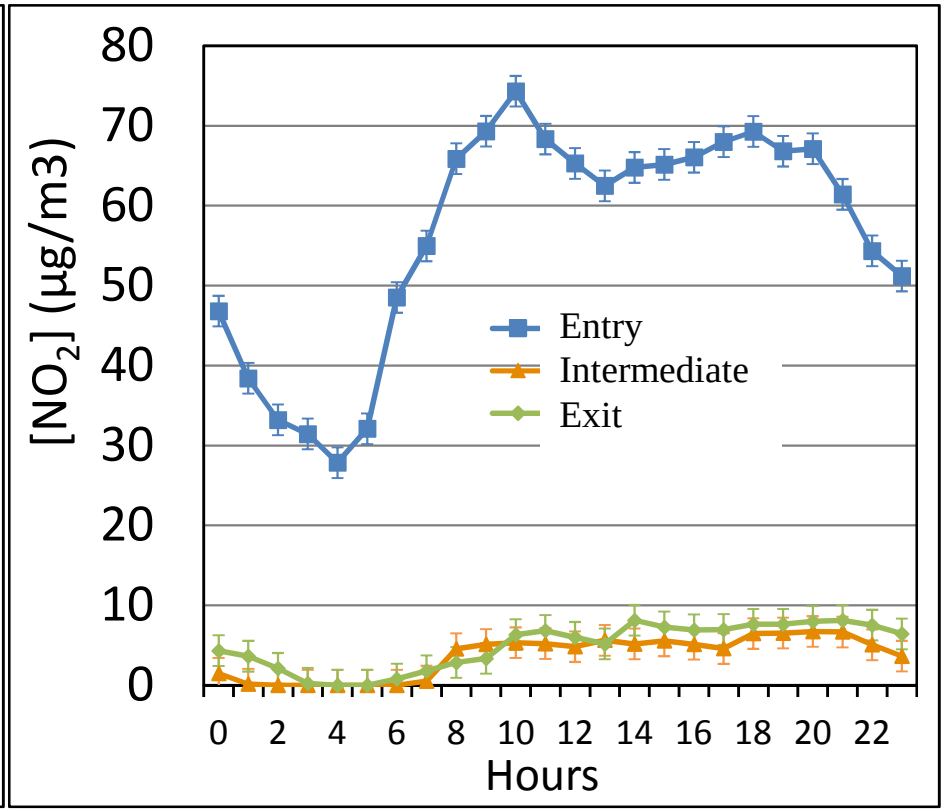

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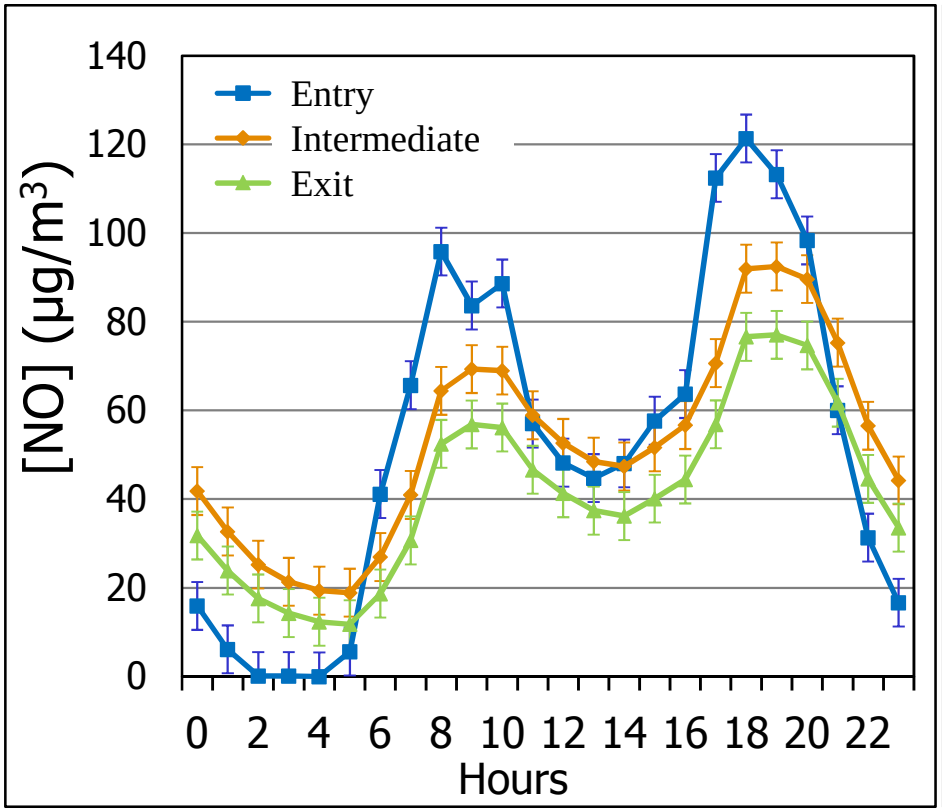
Prototype performances – Results

- Nitrogen oxides : NO



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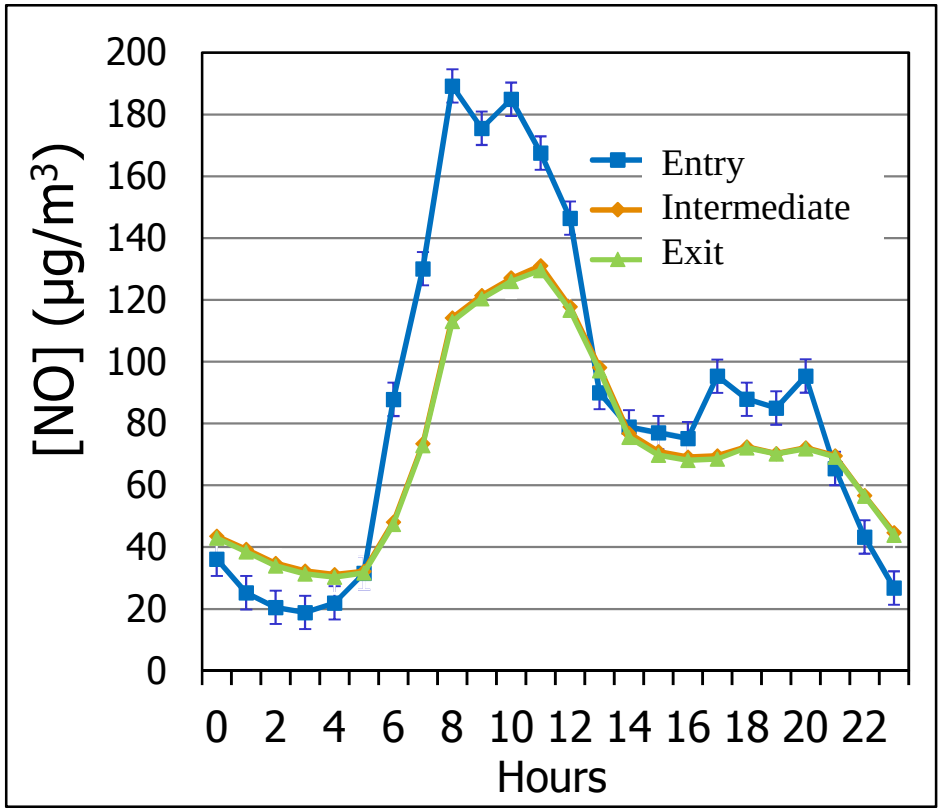

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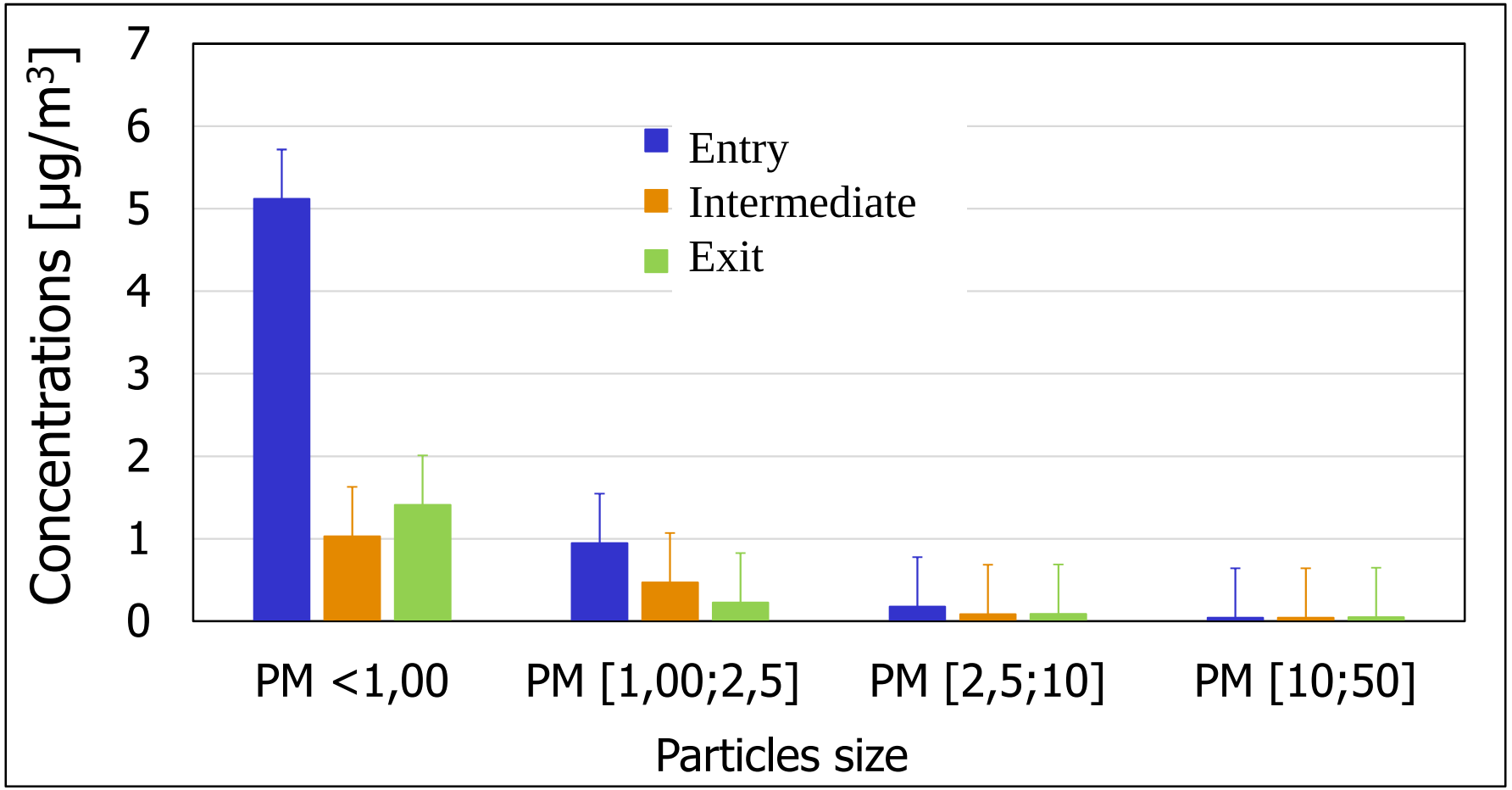
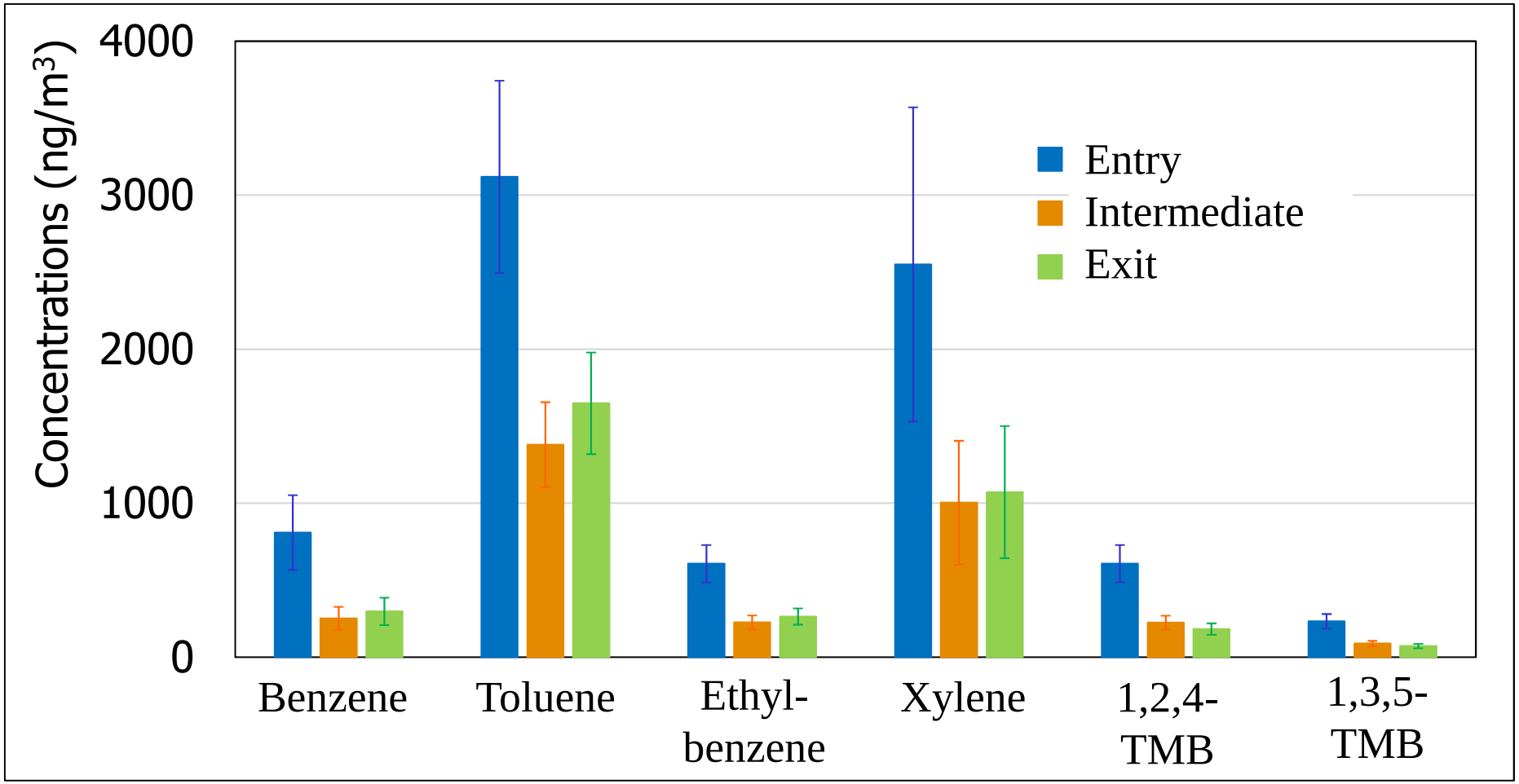
Prototype performances – Results

- PM_1 : main fraction : 80 % of reducing



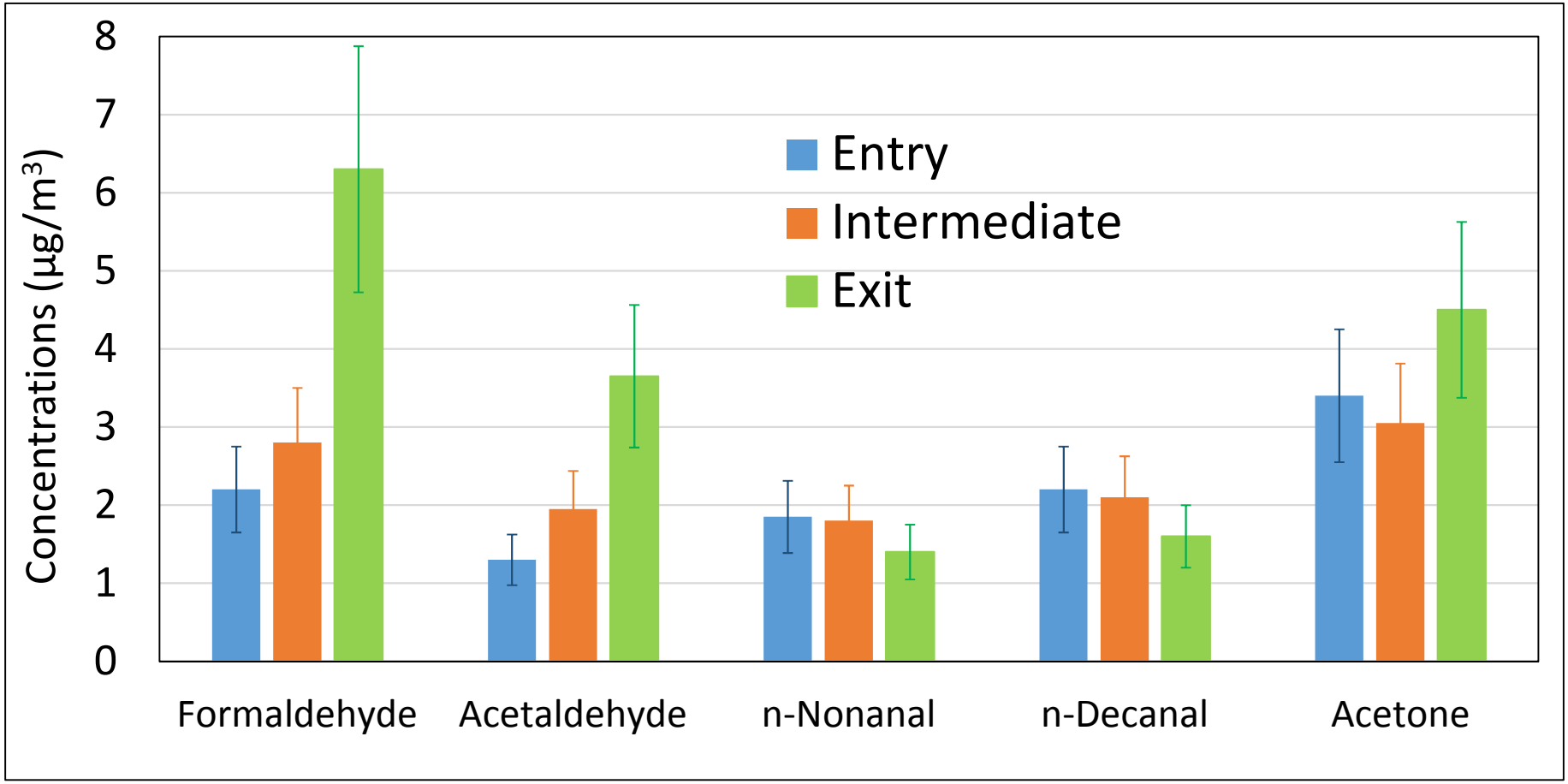
Prototype performances – Results

- VOC : BTEX family



Prototype performances – Results

- VOC : oxygenated compounds : aldehydes + acetone



Conclusions & Perspectives

- Multidisciplinary project : process engineering, microbiology, chemistry, evaluation of energetic consumption, thermic, environmental impact (LCA)
- Characterization of site for various air compounds : gaseous, particulate and biologic
- Characterization of air treatment prototype including adsorption, filtration and photocatalysis techniques
  - in situ measurements during 10 months
  - for various parameters (flow, temperature, humidity) and various compounds (NO_X, PM, VOCs)
  - photocatalysis process in real conditions: formation of secondary compounds in low quantity : NO_2, oxygenated VOC, others compounds ?
- Preconisation : Charcoal Filter + Photocatalysis + Charcoal Filter

Thank you for your attention

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