Technical Research Presentations

IEA EBC - Annex 86 (09/07/2021)

IMPACTS OF CLIMATE CHANGE ON THE INDOOR AIR OF RESIDENTIAL BUILDINGS IN BELGIUM

(OCCuPANt Project - Uliège – 2020-23)

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Introduction

Effects of Climate Change (Global Warming) on Indoor Air Quality (IAQ)

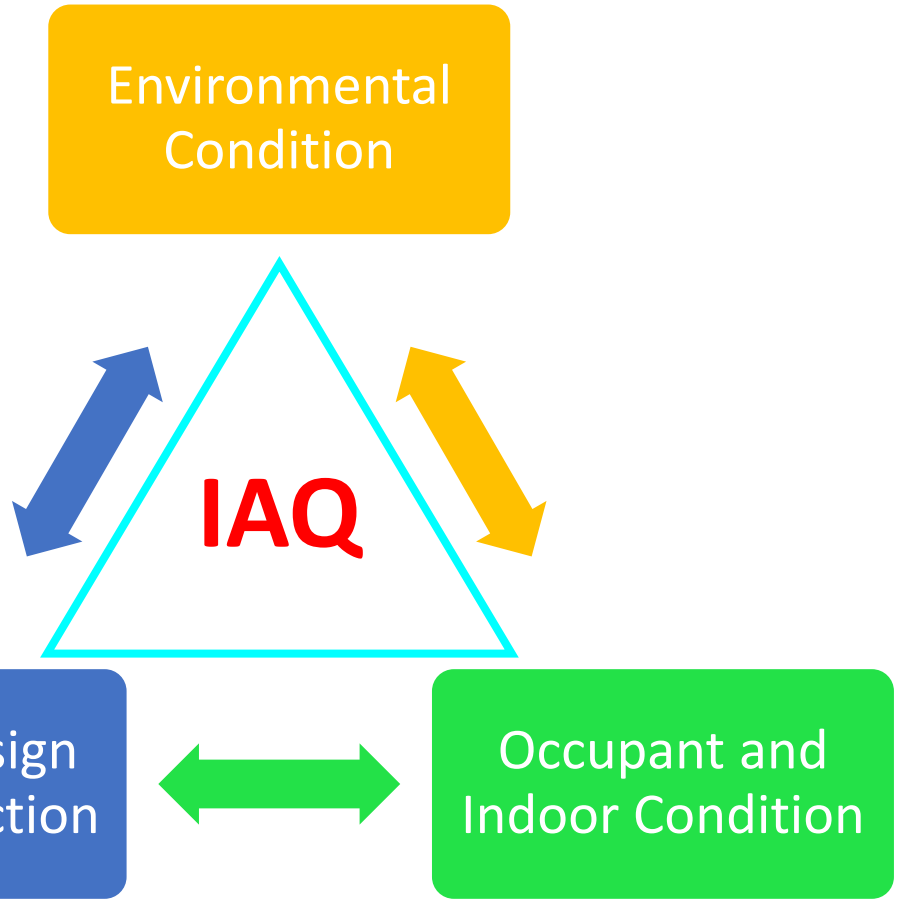
Climatological Effect	Indoor Environmental Effect
Outdoor temperature rise & Extreme heat waves	Indoor **temperature** rises, Increased use of **air conditioning**, Potential for increased off-gassing of **VOC**s, Inability of air conditioning to condition indoor air, Extreme **heat stress**.
Increased outdoor pollution	Increased **PM** & **O_3** indoor, **etc**. O_3 can induce byproducts (indoor chemistry).
Increased mean outdoor humidity & Extreme precipitation episodes	Indoor **RH**, Indoor condensation, and mold growth, **Damp** conditions, building damage.
Pressure to reduce energy use to lower GHG (reduced air ventilation)	All existing indoor pollutants rise in inverse proportion to **reduced ventilation**.

Ref: The Indoor Environments Division Office of Radiation and Indoor Air U.S. Environmental Protection Agency 2010

Introduction

IAQ in the context of Indoor Environmental Quality (IEQ) and Climate Change (CC)

- outdoor pollutants
- ground level O_3 (affected by T, SI)
- dispersion properties of contaminant around the building
- season of the year



- building materials
- HVAC systems
- building airtightness
- ventilation rate
- infiltration rate
- spatial layout

- combustion sources and cooking activities
- chemical-rich products
- occupancy
- tobacco smoke
- human metabolism
- office machines
- opening of windows
- extractor fans
- occupancy pattern
- secondary pollutants
- pet

Research Questions

Research Central Questions

1. What are the most influential factors of CC on the IAQ of residential buildings?
2. What are the links between heatwaves/urban-overheating and outdoor air pollution and IAQ?
3. How to combine thermal comfort and healthy IAQ?
4. How to adapt selected existing IAQ evaluation approaches to provide a useful tool in the context of CC?

Objectives and Aims

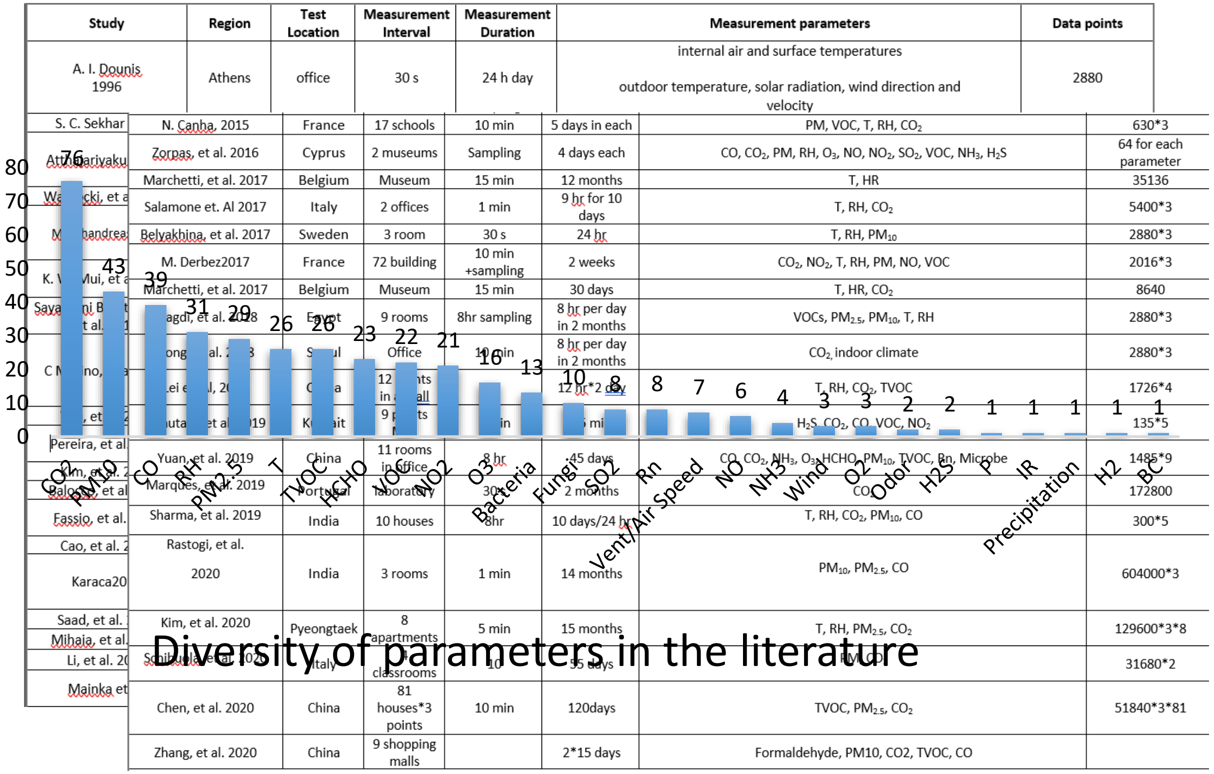
- The project aims to investigate the climate change impacts on the IAQ.
- A decision supporting tool (IAQ-CC index) considering both conditions of indoor and outdoor environments is being developed for supporting the reduction of CC effects on the IAQ levels.

Material and Methods

Correlated CC-Indoor air data

Difficulties and Limitations:

- Variety of parameters
- Diversity of links to the CC



Study	Region	Test Location	Measurement Interval	Measurement Duration	Measurement parameters	Data points
A. I. Dounis 1996	Athens	office	30 s	24 h day	internal air and surface temperatures; outdoor temperature, solar radiation, wind direction and velocity	2880
N. Canha, 2015	France	17 schools	10 min	5 days in each	PM, VOC, T, RH, CO_2	630*3
Zorpas, et al. 2016	Cyprus	2 museums	Sampling	4 days each	CO, CO_2, PM, RH, O_3, NO, NO_2, SO_2, VOC, NH_3, H_2S	64 for each parameter
Marchetti, et al. 2017	Belgium	Museum	15 min	12 months	T, HR	35136
Salamone et. Al 2017	Italy	2 offices	1 min	9 hr for 10 days	T, RH, CO_2	5400*3
Belyakhina, et al. 2017	Sweden	3 room	30 s	24 hr	T, RH, PM_{10}	2880*3
M. Derbez2017	France	72 building	10 min +sampling	2 weeks	CO_2, NO_2, T, RH, PM, NO, VOC	2016*3
Marchetti, et al. 2017	Belgium	Museum	15 min	30 days	T, HR, CO_2	8640
[illegible]agdi, et al. 2018	Egypt	9 rooms	8hr sampling	8 hr per day in 2 months	VOCs, $PM_{2.5}$, PM_{10}, T, RH	2880*3
[illegible]	[illegible]	Office	10 min	8 hr per day in 2 months	CO_2, indoor climate	2880*3
[illegible]	[illegible]	12 [illegible]	[illegible]	12 hr*2 day	T, RH, CO_2, TVOC	1726*4
[illegible] 2019	Kuwait	9 [illegible]	[illegible]	[illegible]	H_2S, CO_2, CO, VOC, NO_2	135*5
Yuan, et al. 2019	China	11 rooms in office	8 hr	45 days	CO, CO_2, NH_3, O_3, HCHO, PM_{10}, TVOC, Rn, Microbe	1485*9
Marques, et al. 2019	Portugal	laboratory	30[illegible]	2 months	CO_2	172800
Sharma, et al. 2019	India	10 houses	8hr	10 days/24 hr	T, RH, CO_2, PM_{10}, CO	300*5
Rastogi, et al. 2020	India	3 rooms	1 min	14 months	PM_{10}, $PM_{2.5}$, CO	604000*3
Kim, et al. 2020	Pyeongtaek	8 apartments	5 min	15 months	T, RH, $PM_{2.5}$, CO_2	129600*3*8
[illegible] 2020	Italy	[illegible] classrooms	10	55 days	[illegible]	31680*2
Chen, et al. 2020	China	81 houses*3 points	10 min	120days	TVOC, $PM_{2.5}$, CO_2	51840*3*81
Zhang, et al. 2020	China	9 shopping malls		2*15 days	Formaldehyde, PM10, CO2, TVOC, CO	

Diversity of parameters in the literature

Different measurement approaches:

- Data Points: [42 – 3,112,000]
- Measurement time Intervals: [30s – 8hr]
- Measurement Duration: [20 min – 15 months]

Material and Methods

Developed IAQ monitoring device / Uliège – SAM

Selection Criteria:

- Most effective based on trends observed in experiments
- Cost and time efficiency
- Practically feasible

Parameters and sensors calibration:
VOC, CO, CO_2, O_3, NO, NO_2, $PM_{2.5}$, PM_{10}, T, RH

Measurement Time Interval:

- 1 min

Material and Methods Data Collection

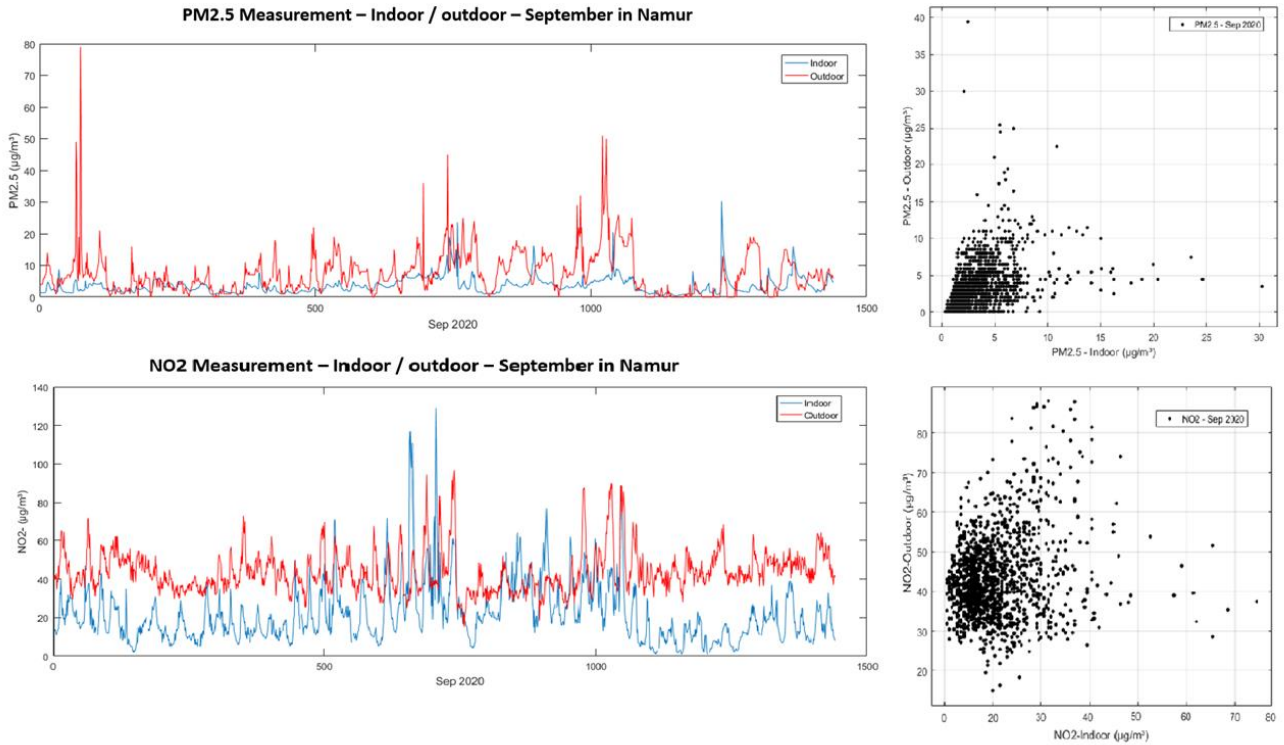
IAQ data collection (2020-21)

Measurement locations:

- 2020: Liege/Namur (2 houses)
- 2021: Habay/Arlon (4 houses)

Data recording time:

- Summer 2020, 2021



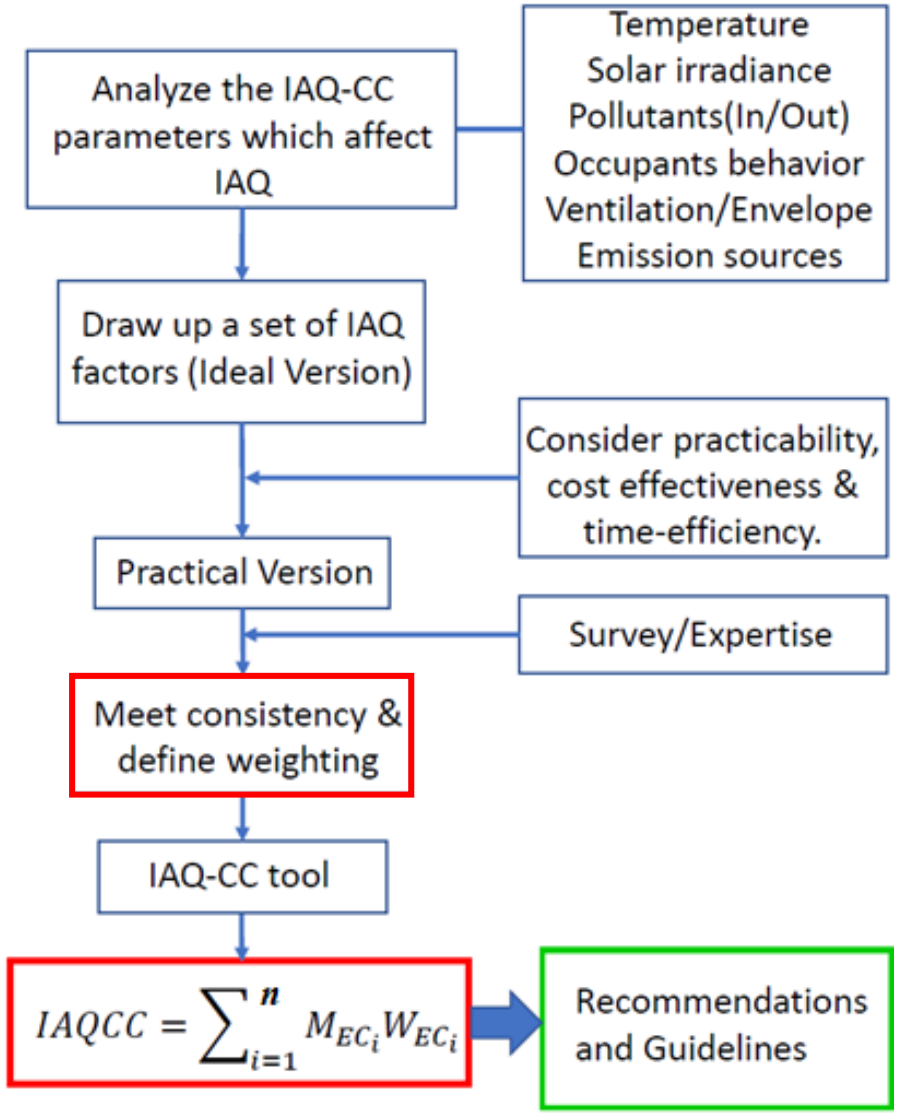
1st evaluation of 2020 measurement campaign

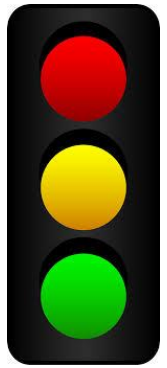
The Occupant-Building Comprehensive **Questionnaire**:

- Questionnaire regarding fixed parameters,
- Daily time table of the occupants activities (occupancy pattern, activities, ventilations)

Material and Methods

Index Development





- Low (Undesirable quality)
- Moderate (Ordinary quality)
- Desired (High quality)

Material and Methods

IAQ Modeling - CONTAM

Analysis:

- **Calculating Airflows**: assessing building air change rates and interzonal airflow rates
- **Analyzing Ventilation Strategies**: Design and compare
- **Simulating Contaminant Transport**: contaminant source isolation, IAQ investigations, and occupant exposure analysis.

5 tasks to perform a multizone analysis with CONTAM:

1. Representing the building as a set of zones and airflow paths
2. Schematic representation (a floor plan)
3. Define building components
4. Simulations
5. Review results.

Conclusions

- In order to evaluate the effects of CC on the IAQ, a decision supporting tool (index) is being developed.
- Practical parameters of IAQ was selected for the monitoring, based on the selection criteria .
- To find the proper weights for the index, measurement campaigns with the developed IAQ devices was carried out in selected test locations.
- The most influential IAQ parameters is being employed to design the IAQ-CC index.
- The IAQ model for the test locations will be developed in the next step.
- With the input data of **future weather models** for the **designed IAQ model** and help of **IAQ-CC index** the impacts of CC on IAQ will be examined.

Thanks for Your Attention

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S.A.M.

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