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Preliminary indoor and outdoor air pollution investigation in naturally ventilated classrooms: results from the ARIA project

Joana Madureira, João Rufo, Inês Paciência, Eduardo de Oliveira Fernandes, Lívia Aguiar, Cristiana Pereira and **João Paulo Teixeira***

*WG Member

National Health Institute / Portugal

jpft12@gmail.com

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Scientific context

- Asthma and allergic diseases: important public health problems (300 M people in the World have asthma!).
- Children's time indoors: home and school (~65% of the time at home!).
- School's indoor air is also a health political priority (Parma Declaration, 2010).
- Few studies linking schools and home indoor environments and children's health.

Objectives

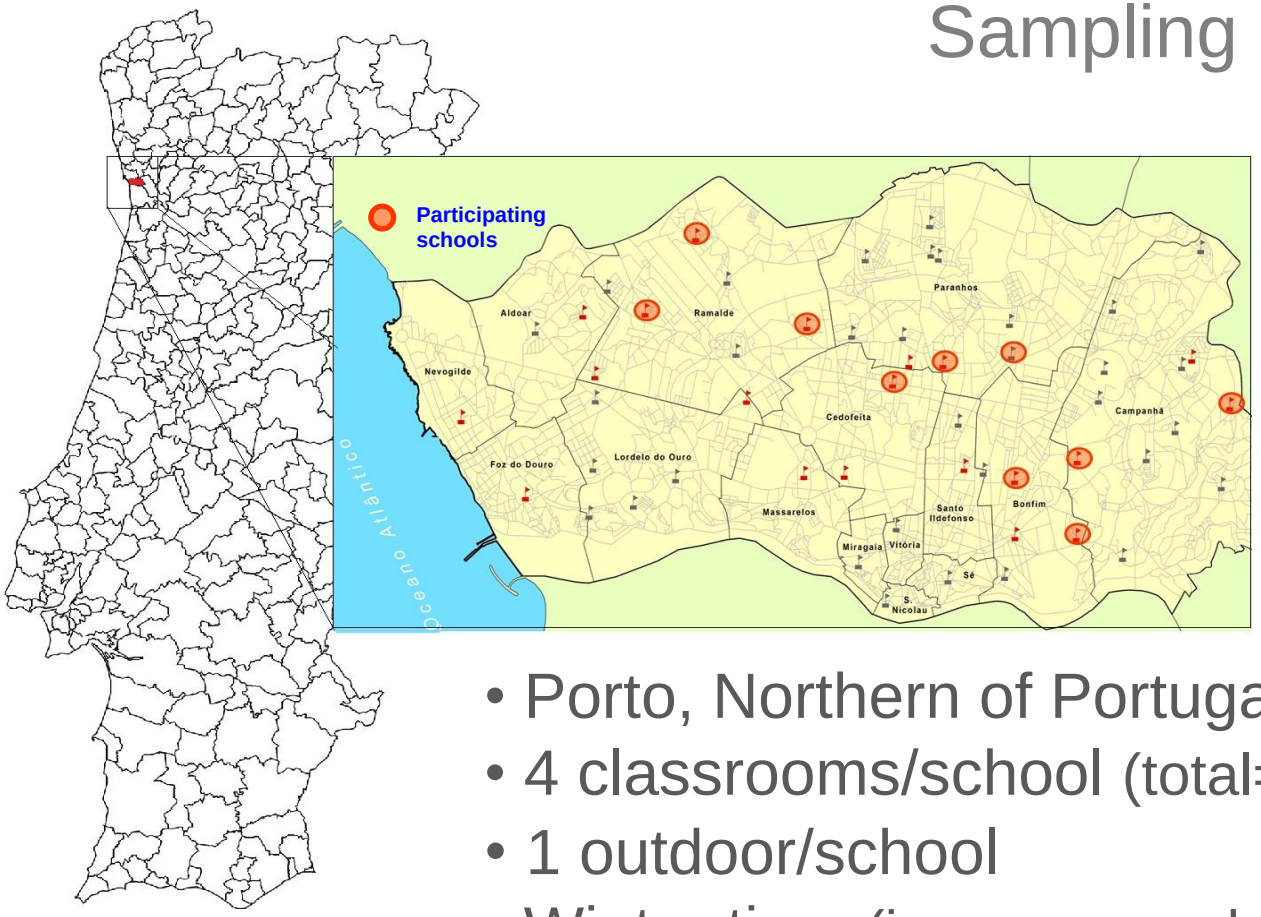
as part of an ongoing ARIA project

to explore associations between various exposures that children, with detected evidence of respiratory disease, experience in indoor environments (specifically their homes and primary schools) and their well-being and health.

Preliminary findings from field studies in 10 primary schools in Porto, Portugal, in which physical, chemical and biological agents were characterized in 35 classrooms.

Material and methods

Sampling sites & study design



- Porto, Northern of Portugal
- 4 classrooms/school (total=10 schools, 35 classrooms)
- 1 outdoor/school
- Winter time (january-march 2014)
- Occupation period only (recess periods not considered)

Material and methods

- **TVOC** [1]
- **Formaldehyde** [2]
- **$PM_{2.5}$** [3], **PM_{10}** [3], **UFP** [4]
- **CO_2** [5]
- **Temperature and RH** [5]
- **Bacteria and fungi** [6]

Indoor and outdoor sampling

Diffusive samplers and consecutive analysis

Optical light scattering

[3] [4]

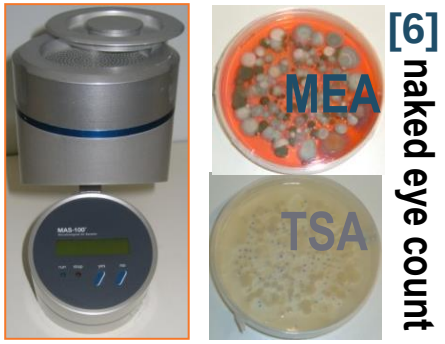
Continuous logger

[5]

Infrared non-dispersive sensor (CO2); Thermistor (T); Thin-film capacitive sensor (RH)

Impaction and consecutive analysis

[6]



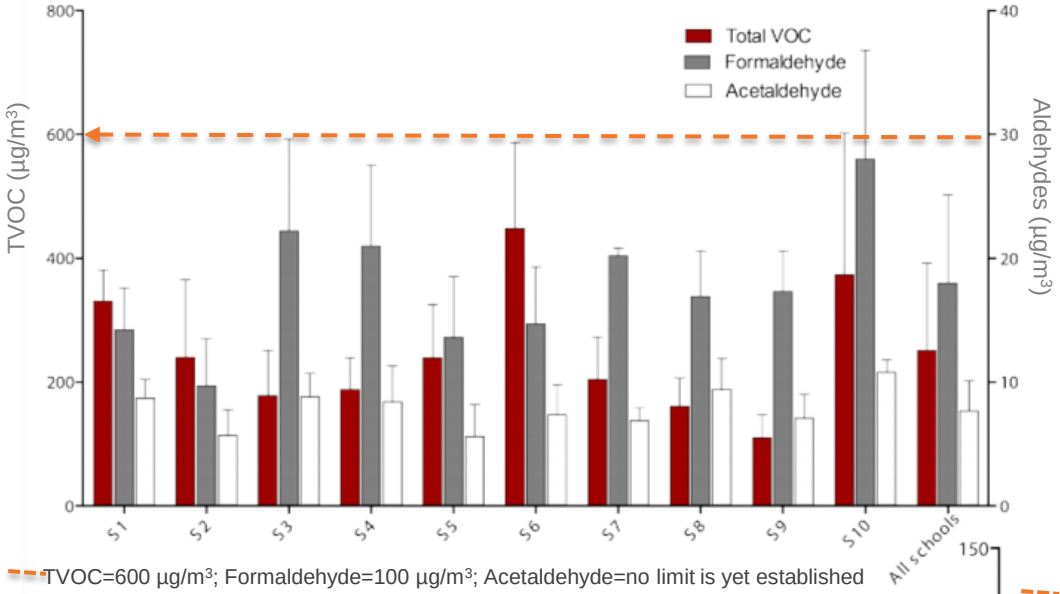
NIOSH 0800 and EN 13098 methods

Material and methods

Indoor and outdoor sampling

IAQ Parameter	Method	Instrument	Analysis	Period
Volatile organic compounds (VOC)	Passive diffusion	Tenax TA stainless steal tubes	GC-MS	1 school week (Monday to Friday)
Formaldehyde and acetaldehyde	Passive diffusion	Radiello passive samplers	HP-LC	1 school week (Monday to Friday)
PM10 and PM2.5	Gravimetry	SKC portable pumps coupled with PTFE filters	- -	8 hours per sampling place
Ultrafine particles (UFP)	(Optical)	P-Track model 8525	- -	8 hours per sampling place (1 min logging intervals)
Bacteria and fungi	NIOSH 0800 and EN 13098 methods	Merck Air Sampler MAS-100	Naked eye count with Fellers law correction	10 min per sampling place
Carbon dioxide (CO2)	Infrared non-dispersive sensor	TSI IAQ-CALCTM monitor (model 7545)	- -	5 school days per classroom (Monday to Friday, 5 min logging intervals)
Relative humidity (RH)	Thin-film capacitive sensor	TSI IAQ-CALCTM monitor (model 7545)	- -	5 school days per classroom (Monday to Friday, 5 min logging intervals)
Temperature	Thermistor	TSI IAQ-CALCTM monitor (model 7545)	- -	5 school days per classroom (Monday to Friday, 5 min logging intervals)

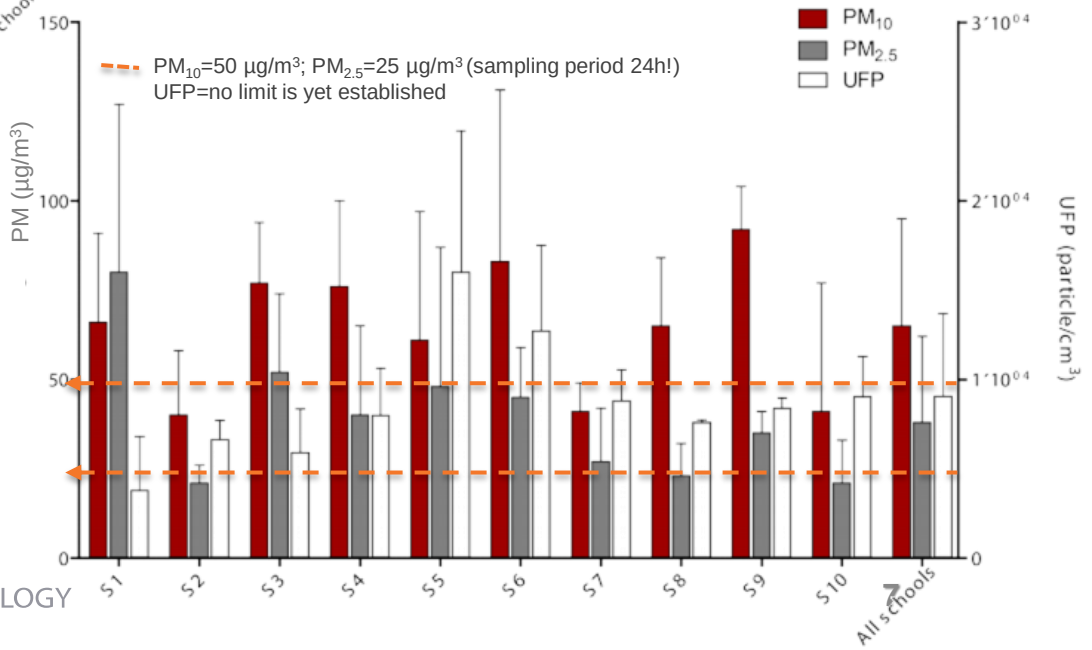
Results - indoor concentrations



TVOC=600 µg/m³; Formaldehyde=100 µg/m³; Acetaldehyde=no limit is yet established

- Indoor VOCs usually originate from products used in occupancy-related activities such as cleaning products or in school artwork.
- Aldehydes can have their origin in wood-based furniture, cork ceilings or paint.

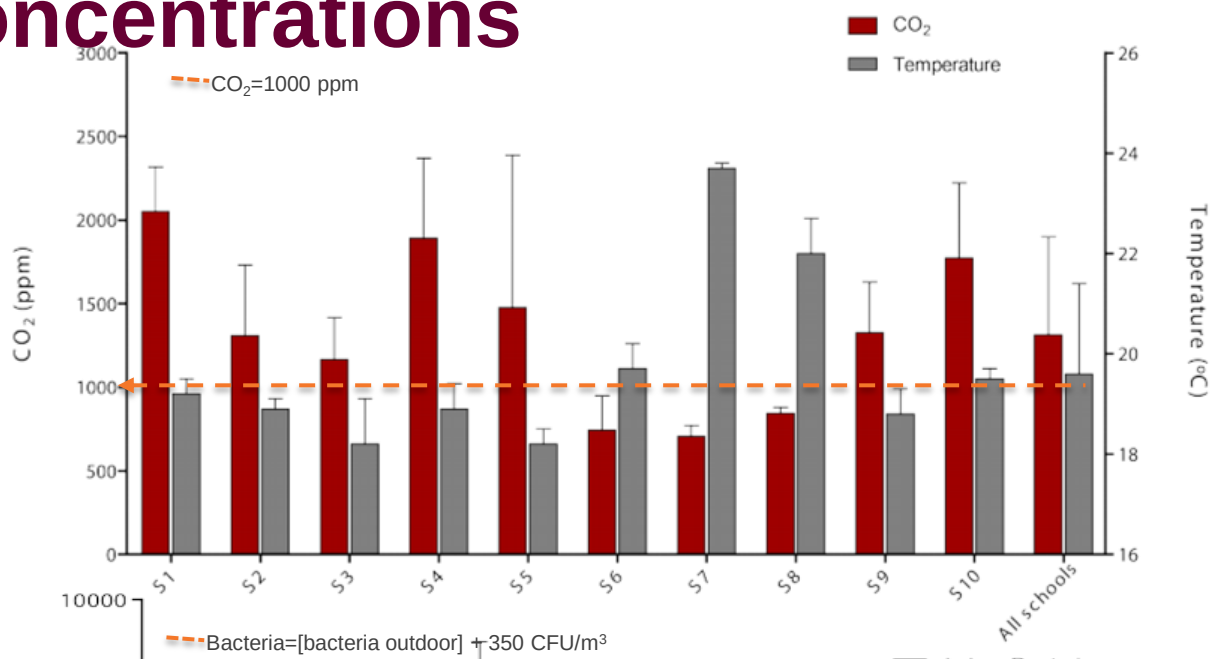
- Outdoor sources and indoor occupant activities, respectively, are suspected/pointed to be the main sources for the levels of $PM_{2.5}$ and PM_{10} indoors.
- Outdoor emissions significantly contributed to UFP indoors.



PM_{10}=50 µg/m³; $PM_{2.5}$=25 µg/m³ (sampling period 24h!)
UFP=no limit is yet established

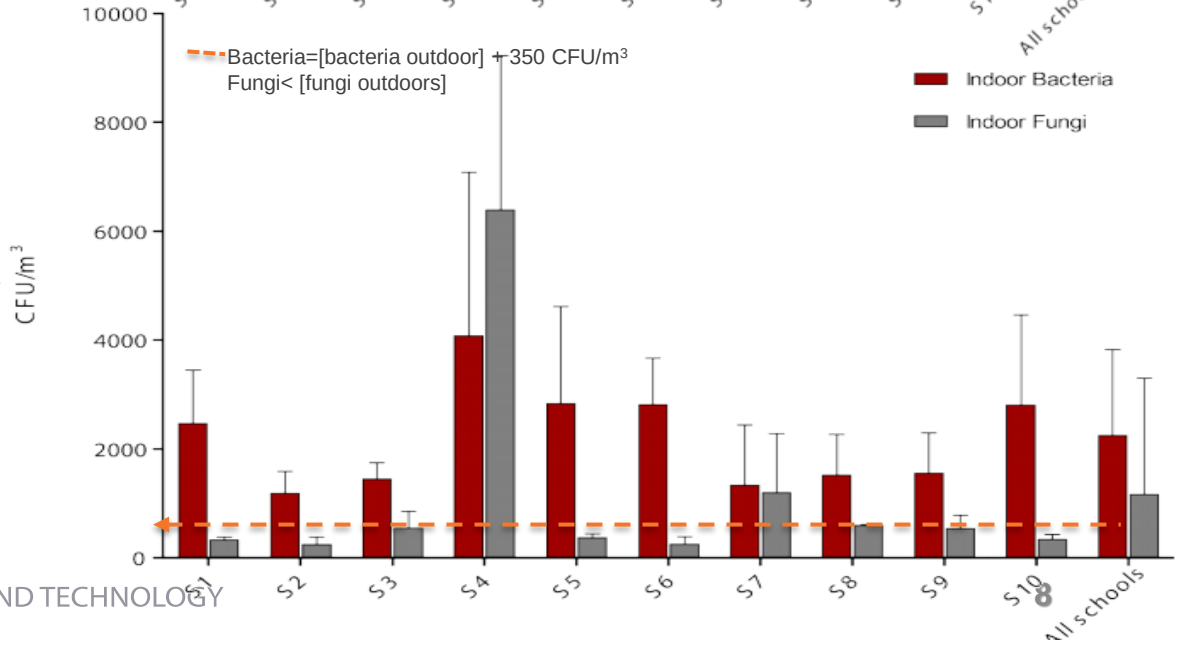
Results - indoor concentrations

- Insufficient ventilation, as indicated by CO_2 levels, appears to be a common IAQ problem for almost all the schools (median levels above 1000 ppm).
- Importance of occupant behaviours in the control and guarantee of good IAQ, using CO_2 as a proxy.



- No comparisons can be made in relation to WHO guidance and EU limit values. Only in very few countries guidance values have been established (e.g. Portugal).

- Median concentration of bacteria higher than 1000 CFU/m^3!



Results - indoor/outdoor ratios

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Total
TVOCs	11,1	2,3	2,6	2,6	1,2	3,2	1,9	1,1	1,2	0,7	1,6
Formaldehyde	10,9	2,5	11,4	18,6	4,3	9,9	8,1	11,5	11,4	22,2	9,2
Acetaldehyde	20,7	4,6	15,9	18,7	1,7	6,9	2,4	3,1	6,8	17,7	5,4
PM10	1,5	0,6	1,4	10,8	2	1,8	1,5	1,4	3	3,4	1,8
PM2.5	1,6	0,4	1,7	1,5	2,7	2,1	0,6	0,5	2,3	N/A	1,2
UFP	1,8	0,9	0,3	2,5	1,8	1,3	0,8	0,7	0,8	1	1
Bacteria	6,2	12,1	32,8	42,5	16,3	704,8	30,3	42,3	2,3	1,8	7,2
Fungi	0,8	1,4	4,4	40	1,9	2,1	11,1	6,5	0,9	1,3	5,3
CO2	6,7	3,5	3,7	6,1	4,9	2,5	2,6	3	5,9	8,1	4,5

- High I/O ratio (I/O>5): [d-limonene], CO_2, formaldehyde, acetaldehyde, bacteria, fungi
- Moderate I/O ratio (~2): TVOCs, [toluene], PM_{10}
- Low I/O ratio (I/O<1): $PM_{2.5}$, [benzene]

Final remarks

- CO_2, particulate matter and bacteria levels generally exceeded the established guidelines values.

- High CO_2 levels suggest poor ventilation in schools, which may be responsible for the increased concentrations of other pollutants.

- Opening the windows during school breaks may be a solution to overcome this problem.

- Exposure to indoor air is relevant to children's health overall; exceedances of certain parameters (PM, CO_2, bacteria levels in classrooms) indicate the need to implement programs in order to further improve IAQ by, firstly, controlling pollutant sources.

Perspectives towards the future

- The ARIA project will study the tendencies of IAQ parameter concentrations associated with classroom and building characteristics.

- The results from the children's clinical evaluation may further clarify the health risks of exposure to air pollutants in schools and their impact on the development of asthma and allergy.

Project research team and funding

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Publications

Journal of Toxicology and Environmental Health, Part A, 75:1423–1436, 2012

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LEVELS AND INDOOR–OUTDOOR RELATIONSHIPS OF SIZE-SPECIFIC PARTICULATE MATTER IN NATURALLY VENTILATED PORTUGUESE SCHOOLS

Joana Madureira, Inês Paciência, Eduardo de Oliveira Fernandes

Institute
Porto, P

Journal of Toxicology and Environmental Health, Part A, 77:816–826, 2014

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IDENTIFICATION AND LEVELS OF AIRBORNE FUNGI IN PORTUGUESE PRIMARY SCHOOLS

Joana Madureira[1], Cristiana Pereira[2], Inês Paciência[1], João Paulo Teixeira[2], Eduardo de

[1]Institute of
Portugal
[2]National Ins

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Assessment and determinants of airborne bacterial and fungal concentrations in different indoor environments: Homes, child day-care centres, primary schools and elderly care centres

Joana Madureira [a, *], Inês Paciência [a], João Cavaleiro Rufo [a], Cristiana Pereira [b], João Paulo Teixeira [b, c], Eduardo de Oliveira Fernandes [a]

[a] *Institute of Science and Innovation in Mechanical Engineering and Industrial Management, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal*
[b] *Environmental Health Department, National Institute of Health, Rua Alexandre Herculano, 321, 4000-055 Porto, Portugal*
[c] *Public Health Institute, University of Porto, Rua das Taipas 135, 4050-600 Porto, Portugal*

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Thank you!

João Paulo Teixeira

WG Member

National Health Institute / Portugal

jpft12@gmail.com

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