Breath IN towards a better and sustainable indoor air quality environment

Workshop
Breath IN Project

/ Indoor air quality environment and well-being
/ Energy, climate change and sustainability

INDOOR ENVIRONMENTAL QUALITY IN SUPPORT OF WELLBEING AND SUSTAINABILITY

BOOK OF ABSTRACTS

13-14 November, 2025
Leiria, Portugal

Funded by the European Union

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Program at a glance

November 13, 2025
(*Auditorium ESSLei, IPLeiria*)

9:00 **Registration**

9:15 **Opening Ceremony**

Fernando Silva, Deputy Director, School of Technology and Management (ESTG), Polytechnic University of Leiria

Rui Pinto, Director, School of Health Sciences (ESSLei), Polytechnic University of Leiria

Pedro Assunção, Vice President, Polytechnic University of Leiria

9:45 **Musical Moment**

10: 00 **KeyNote Lecture: Indoor Air Quality in Day Care Centres**

Dr. Manuela Cano, National Institute of Health Doutor Ricardo Jorge, PT

10:30 **Leiria Smart City: Towards Improving the Air We Breathe**

Dr. Hugo Bogalho, Municipality of Leiria, PT

10:50 **Coffee break**

11:20 **Classroom environmental perceptions: a Breath IN approach**

Prof. Francisco Carvalho, Polytechnic University of Tomar, PT

11:40 **Trends in temperature-related mortality and signs for maladaptation to heat and cold in the eastern Mediterranean**

Prof. Anastasia Paschalidou, Democritus University of Thrace, GR

12:00 **Breathing Knowledge: Advancing Indoor Air Quality in Higher Education Environments**

Prof. Cristina Andrade, Polytechnic Institute of Tomar, PT

12:20 **Concluding remarks – Discussion**

November 14, 2025

(Meeting Room. Building B, ground floor, ESTG - hybrid event)

10:30 **Introduction**

Prof. Sandra Mourato, Polytechnic University of Leiria, PT

10:40 **Adaptive Building Systems for Energy Efficiency and Human-Centric Environmental Management**

Prof. Katariina Penttilä; Prof. Timo Viitala & Prof. Timo Väisänen, Häme University of Applied Sciences - HAMK, FI

11:00 **Characterization of indoor environment in a university setting in Cyprus**

Eleanor Arati Roy, Evelina Kirzhbaum, Amir Martin Mansouri, Edna N. Yamasaki & Souzana Achilleos. University of Nicosia, CY

11:20 **Real-Time Dashboard for Monitoring and Analysis of Indoor Environmental Quality in Classrooms**

Ing. Rodrigo Medina, Polytechnic University of Leiria, PT

11:40 **Synergies between IEQ and energy efficiency monitoring - a practical example of the NUDGE project**

PhD Zenaida Mourão, Institute for Systems and Computer Engineering, Technology and Science, PT

12:00 **Discussion**

Abstracts

Indoor Air Quality in Day Care Centre

Manuela Cano

Institute of Health Doutor Ricardo Jorge

The growing concern about indoor air quality (IAQ) results from the knowledge that exposure to indoor air pollutants may be higher than outdoor air exposure. In developed countries, after their homes, day care centres are the places where children spend most of their time, so it is essential to understand how environmental factors influence children health.

The objectives of the ENVIRH study (2010-2012) were to assess IAQ in naturally ventilated day care centres and kindergartens located in urban centres, study the correlations between indoor air pollutants and explore differences in the associations between building characteristics and IAQ in spring and winter. Most of the day care centres revealed carbon dioxide and bacterial levels above the reference levels defined by the Portuguese legislation, Indoor PM10 levels were higher indoors when compared with outdoor levels (I/O ratio>1) and are influenced by the floor covering materials.

Recent changes to indoor air quality regulations, implemented in 2020, require a simplified assessment of indoor air quality in nurseries and kindergartens, with the determination of carbon dioxide and particulate matter (PM10/ PM2.5). The results of some recently conducted simplified annual assessments will be presented and discussed.

Leiria Smart City: Towards Improving the Air We Breathe

Hugo Bogalho

Municipality of Leiria

Leiria Smart City is a municipal programme that integrates environment, mobility and digital tools to support more sustainable urban development. In this presentation, we focus on air quality as a central dimension of public health and quality of life. The project includes a network of environmental sensors that monitor air pollutants (CO, NO_2, O_3, SO_2, VOC, PM_1, $PM_{2.5}$ and PM_{10}), meteorological variables, noise and traffic in near real time, feeding management and public information platforms. Although the monitoring system is still at an early stage and long-term historical data are not yet available, the strategy already defines how this information will be used: to support local decision-making, raise public awareness, and link air quality with mobility and land-use policies. The presentation will describe the main components of the system, the governance model and next steps towards making air quality data a practical tool for both citizens and decision-makers.

Classroom environmental perceptions: a Breath IN approach

Francisco Carvalho & Cristina Andrade

Polytechnic University of Tomar

Indoor air quality (IAQ) in higher education buildings has become increasingly important in the context of public health, environmental comfort, and academic performance. Educational institutions, traditionally designed with a focus on functionality and occupancy density, are becoming spaces with high daily occupancy and, consequently, potential locations of continuous exposure to indoor pollutants. The presence of carbon dioxide (CO_2), volatile organic compounds (VOCs), fine particulate matter ($PM_{2.5}$ and PM_{10}), as well as inadequate ventilation conditions and excessive temperatures, have been associated with symptoms of discomfort, fatigue, headaches, respiratory irritations, and the worsening of pre-existing conditions such as asthma, allergic rhinitis, and other respiratory or cardiovascular conditions.

Beyond the physiological impacts, the subjective perception of indoor environmental quality plays a decisive role in the experience of those who use learning spaces. Studies such as Brink et al., 2021; Tamran et al., 2025; or Gomes et al., 2025, show that perceptions of "stale" air, thermal discomfort, or excessive noise negatively influence concentration, well-being, and cognitive performance. This perceptual dimension, often neglected in purely technical assessments, constitutes an important indicator of environmental quality and acceptability by users, students, teachers, researchers, technicians, and other long-term users of these spaces.

A study conducted in spaces subject to different conditions was aimed at students and teachers, with the aim of understanding the perception that users of these spaces have about how IAQ interferes with pre-existing health conditions, or how they perceive their worsening, when compared to staying in open spaces.

The results of this survey are analyzed, presenting conclusions that support the hypotheses underlying the study within the scope of the Breath IN project.

References

Brink, H. W., Loomans, M. G. L. C., Mobach, M. P., & Kort, H. S. M. (2021). *Classrooms' indoor environmental conditions affecting the academic achievement of students and teachers in higher education: A systematic literature review.* Indoor Air, 31(2), 405–425. https://doi.org/10.1111/ina.12745

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Gomes, M. I., Barreiros, A. M., Pinto, I., & Rodrigues, A. (2025). *Improving indoor air quality in a higher-education institution through biophilic solutions.* Sustainability, 17(11), 5041. https://doi.org/10.3390/su17115041

Trends in temperature-related mortality and signs for maladaptation to heat and cold in the eastern Mediterranean

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2 Medical School, University of Cyprus, Nicosia, Cyprus

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4 Department of Biostatistics and Epidemiology, Rutgers School of Public Health, New Brunswick, NJ, USA

The Eastern Mediterranean region is experiencing temperature rise that surpasses global averages, making it a climate change hotspot. While previous studies have extensively examined the impacts of extreme heat/cold on mortality/morbidity, no research has explored temporal trends in temperature-related mortality or historical adaptation in this region. This study investigates cardiovascular mortality and examines changes over time in the Minimum Mortality Temperature (MMT) and the disease-specific mortality fractions attributable to heat/cold in three representative locations: Athens, Thessaloniki, and Cyprus. Daily cardiovascular mortality and meteorological parameters were available from 1999-2019 for Athens, 1999-2018 for Thessaloniki, and 2004-2019 for Cyprus. Using time-series Poisson regressions with distributed lag nonlinear models, we estimated cardiovascular MMT and mortality fractions, accounting for seasonal and long-term trends through rolling sub-period analyses. Results indicate that in Athens, MMT decreased from 23°C in 1999-2007 to 21.8°C in 2011-2019. Similarly, in Cyprus, MMT dropped from 26.3°C in 2004-2012 to 23.9°C in 2011-2019, while Thessaloniki showed only a slight decrease. Across all locations, the proportion of mortality linked to both heat and cold increased over time. In conclusion, the rising fraction of cold-related mortality and the downward trend in MMT suggest a maladaptive response to extreme temperatures in warm climates.

Key Words: Climate change, adaptation, Minimum Mortality Temperature, Mediterranean region

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Breathing Knowledge: Advancing Indoor Air Quality in Higher Education Environments

Andrade, Cristina[1, 2]; Achilleos, Souzana[4,6]; Barreto, Miguel[7]; Bernardo, Hermano[7,9]; Carvalho, Francisco[1]; Charalambidou, Iris[4]; Costeira, Cristina[8, 10]; Georgiou, Kyriakos E.[4]; Gonçalves, Rui[1]; Mourato, Sandra[7]; Papaloizou, Loizos[4,5]; Paschalidou, Anastasia[3]; Pereira, Sónia Gonçalves[10]; Psistaki, Kyriaki[3]; Sarris, Ernestos[4,5]; Sousa, João[7]; Stathopoulos, Stavros[3]; Veiga, Anabela[7]; Yamasaki, Edna N[4]

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10 Center for Innovative Care and Health Technology (ciTechCare), Polytechnic University of Leiria, Portugal

Indoor Air Quality (IAQ) is a critical determinant of health, comfort, and cognitive performance in higher education institutions, where students and staff spend extensive periods in indoor environments. Despite growing awareness of environmental sustainability, the quality of indoor air remains an under-addressed dimension of academic infrastructure and policy. Poor IAQ—marked by elevated concentrations of carbon dioxide, particulate matter, and volatile compounds—has been shown to impair attention, increase fatigue, and contribute to respiratory and cardiovascular risks. In contrast, well-ventilated and well-monitored learning environments foster well-being, engagement, and academic achievement.

The Breath IN initiative advances this agenda by promoting a systemic understanding of IAQ within universities and by translating research findings into actionable knowledge. Its dissemination strategy combines a Massive Open Online Course (MOOC) for broad academic and professional outreach, a White Book synthesising scientific evidence and institutional practices, and short educational videos designed to engage students, staff, and decision-makers. Together, these tools aim to bridge the gap between scientific research, institutional policy, and public awareness—empowering higher education institutions to adopt evidence-based strategies for healthier and more sustainable indoor environments.

Keywords: Indoor Air Quality (AQI), Higher Education Institutions (HEI), Dissemination strategies, Breath IN project

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Adaptive Building Systems for Energy Efficiency and Human-Centric Environmental Management

Katariina Penttilä, Timo Viitala & Timo Väisänen

Häme University of Applied Sciences. School of Business, Design and Technology, Degree Programme in Electrical and Automation Engineering

This presentation investigates the integration of intelligent building systems in response to contemporary demands for energy-efficient, adaptive, and occupant-centric built environments. The analysis begins by framing the urgency of such systems within the context of energy conservation, rising operational costs, and increasing awareness of indoor air quality (IAQ).

A systemic integration overview highlights the role of interoperable technologies—including IoT devices, automation platforms, and data-driven control systems—in enabling responsive and optimized building operations. Key system inputs and their impacts are examined through the identification of energy-intensive subsystems and the implementation of smart monitoring and optimization techniques, which yield measurable improvements in energy performance.

The concept of adaptive buildings is introduced as a dynamic framework in which environmental conditions, user behavior, and functional requirements inform real-time system responses. Human-centric design principles are emphasized, focusing on usability, personalization, and occupant well-being.

The Nordic context is addressed through region-specific environmental and legislative considerations, with Finnish housing health regulations serving as a baseline. Empirical case studies demonstrate practical applications of IAQ monitoring, enabling data-driven control and continuous improvement of building services.

The presentation concludes with recommendations for systemic thinking and evidence-based decision-making in the design and deployment of intelligent building systems.

Characterization of indoor environment in a university setting in Cyprus

Eleanor Arati Roy[3], Evelina Kirzhbaum[2], Amir Martin Mansouri[3], Edna N. Yamasaki[1,2] & Souzana Achilleos[1,3]

[1]Environmental Health Research Centre, [2]School of Life and Health Sciences, [3]University of Nicosia Medical School

This analysis examines indoor air-quality data collected from September 2024 to July 2025 as part of the BREATH IN project. Using measurements of PM1, PM2.5, PM10, and CO2 from multiple sensors, the analysis revealed noticeable fluctuations in air quality across different periods, reflecting changes in occupancy, ventilation, and environmental conditions. These variations provide insight into the dynamic nature of indoor air environments and contribute to the project's ongoing evaluation of air-quality patterns over time with the goal of promoting healthier and more sustainable indoor spaces.

Real-Time Dashboard for Monitoring and Analysis of Indoor Environmental Quality in Classrooms

Rodrigo Joel López Medina

Polytechnic University of Leiria, PT

This presentation shows the development of an interactive panel in Power BI that allows real-time visualization and analysis of data on the indoor environmental quality of a classroom in a building at the Polytechnic Institute of Leiria.

The project integrates measurements of carbon dioxide (CO2), particulate matter (PM10 and PM2,5), temperature, and relative humidity to assess air quality and comfort conditions in the classroom. The dashboard is designed to provide not only continuous monitoring but also access to historical data, making it easy to identify trends and environmental variations. As the data is updated, visual and comparative indicators help interpret the situation and support evidence-based decision-making.

This tool becomes a key resource for promoting healthy and efficient academic environments, reflecting the institute's commitment to sustainability and smart management of its indoor spaces.

Synergies between IEQ and energy efficiency monitoring - a practical example of the NUDGE project

Zenaida Mourão

Institute for Systems and Computer Engineering, Technology and Science, PT

The presentation will focus on the results of a study of 101 Portuguese families with children, conducted within the H2020 NUDGE project, examined housing conditions, indoor environment quality, and energy behaviors to inform behavioral interventions in residential buildings. The findings of the study showed that a significant share of participants in the study use inefficient heating sources, while limited thermostat adoption restricts traditional energy-saving approaches. The research provided evidence-based insights for developing nudging strategies and policies that promote healthy, energy-efficient homes while combating energy poverty through integrated behavioral change approaches.

Monitoring Air Quality at ESDS for a More Sustainable and Healthy Environment

Beatriz Reis, Érica Carreira, Filipa Nunes, Filipa Marinho, Inês Rodrigues, Leonor Almeida, Victória Salgueiro, Patrícia Medeiros, Sofia Gaspar

Secondary School Domingos Sequeira, Leiria, Portugal

Indoor air quality is a critical determinant of health, well-being, and learning performance. School environments, where students and teachers spend extended periods, may present risks if ventilation is insufficient and pollutants accumulate. This study aimed to assess the microbiological quality of classroom air by analysing bacterial and fungal loads in two classrooms (A109 and A310) at Secondary School of Domingos Sequeira, Leiria (PT), before and after daily occupation, and comparing results with Portuguese legal reference values.

Air samples were collected indoors and outdoors at two time points (08:00 and 17:00) and cultured in TSA and MEA media. Colony Forming Units (CFU/m^3) were quantified and compared with reference conditions. Results showed that bacterial concentrations remained within legal limits, although values tended to increase after classroom occupation. Fungal concentrations, however, exceeded legal criteria in specific cases, with indoor levels surpassing outdoor reference values, particularly in A310 before occupation, suggesting inadequate ventilation or internal contamination sources.

These findings highlight the importance of reinforcing ventilation systems and implementing periodic environmental monitoring in schools. Combined with physicochemical parameters such as CO_2, particulate matter, and illuminance, the results underline the need for an integrated approach to ensuring healthier and more sustainable learning environments.

Breathing Better Begins in the Classroom!

Ana Almeida, Paula Roque, Beatriz Gomes, Beatriz Damásio, Bruno Pereira, Constança Palhares, Duarte Silva, Eric Cheng, Gabrielly Rosa, Gonçalo Tomé, Guilherme André, Lara Gomes, Lara Cunha, Laura Resende, Leonor Silva, Maria silva, Matilde Clérigo, Mélanie Ruivaco, Nuno Simões, Pedro Martinho & Santiago Pinto

Secondary School Pinhal do Rei, Marinha Grande, Portugal

This research project, conducted by 10th-grade students from Pinhal do Rei Secondary School, Marinha Grande, aimed to evaluate indoor air quality in classrooms by applying scientific methodologies to analyse microbiological, physical, and chemical parameters. The study focused on two classrooms (LQ1 and B13) and examined how student presence influences variations in air quality.

Air samples were collected using culture media (TSA for bacteria and MEA for fungi) and an air extractor, while physical and chemical parameters were measured with Air Visual Pro sensors and a lux meter. The analysis revealed bacterial colonies in indoor environments, with significantly higher counts when classrooms were occupied and windows remained closed. Fungal growth was less significant, staying within expected limits.

Measurements of particulate matter ($PM_{2.5}$ and PM_{10}) showed occasional peaks above recommended thresholds, coinciding with high occupancy and limited ventilation. Carbon dioxide concentrations often exceeded 1500 ppm, indicating insufficient air renewal and potential effects on student performance and well-being. Illuminance levels varied with natural light availability, but were frequently below the recommended 350 lux (WHO).

The findings highlight the importance of effective ventilation and lighting strategies in classrooms. Ensuring adequate indoor air quality is essential for safeguarding health and optimising learning conditions in educational settings.

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