CAPSTONE PROJECT: Impacts of climate change on air quality and health: a multidisciplinary approach

Proponent: FIDELIDADE

Description of the Challenge:

Climate change is increasingly affecting air quality and public health through various mechanisms, including rising temperatures, changes in wind and precipitation patterns, and increased frequency of extreme weather events such as heatwaves and wildfires. These environmental changes influence the concentration and composition of air pollutants, affecting population exposure and leading to potential health risks.

This capstone aims to explore the interconnections between climate change, air quality, and health by analysing historical trends, identifying key pollution sources, and assessing health impacts under present and future extreme conditions. A multidisciplinary team of students from the Master's programmes in Environmental Engineering, Mechanical Engineering, Biological Engineering, Bioengineering in Regenerative and Precision Medicine, Biomedical Engineering, and Microbiology, will collaborate to provide a holistic understanding of the challenge and propose mitigation strategies with co-benefits for climate, air quality, and health.

Advisory Team:

Marta Almeida, DECN (Coordination)

Patrícia Baptista, DEM

Tiago Fernandes, DBE

Jorge Leitão, DBE

Vânia Martins, DECN

Tiago Faria, DECN

Master's Programmes Eligible for this Capstone:

Master in Environmental Engineering (MEAmb)

Master in Mechanical Engineering (MEMec)

Biological Engineering (MEBiol)

Bioengineering in Regenerative and Precision Medicine (MBMRP)

Master in Biomedical Engineering (MEBiom)

Master in Microbiology (MMicro)

General context:

Climate change is expected to intensify the frequency and severity of extreme weather events, significantly affecting air quality and public health. Future projections indicate that prolonged heat waves, shifting wind patterns, and increased wildfire occurrences will exacerbate air pollution, leading to greater respiratory and cardiovascular risks. Understanding these trends is essential for developing effective mitigation and adaptation strategies.

This capstone project will analyse historical climate, air quality, and health data in selected regions of Portugal to identify correlations and assess risks. Through a multidisciplinary approach, the research will evaluate the health impacts of air pollutants in urban environments under current conditions and extreme scenarios representing potential future developments. Additionally, it will identify key emission sources and propose mitigation measures to enhance air quality and public health outcomes.

Work thesis assignments:

The first semester of this capstone project will focus on collaborative work, involving all students in defining the challenge, establishing global objectives, and aligning interdisciplinary contributions. Students will conduct a comprehensive literature review on climate change projections, associated air pollution trends, health impacts, and relevant technological developments. This review will guide the scope of the study and serve as the foundation for four interconnected research theses:

Thesis #1: This thesis investigates how air quality in Portugal varies across regions and time, with a focus on extreme weather events and their health impacts. It explores correlations between pollutant levels and public health outcomes, aiming to assess the broader health burden of air pollution under changing climate conditions. The study draws on data from hospital admissions, APA, IPMA, ISRJ, and other relevant institutions.

Thesis #2: Chemical characterization of atmospheric particles in Lisbon and application of receptor models to quantify the contribution of emission sources and explore mitigation options. The potential impact of relevant technological developments on future air quality will also be explored.

Thesis #3: Assessment of airborne particle deposition in the human respiratory system across various urban microenvironments and extreme air pollution events. Particle characteristics will be analysed under current conditions and future scenarios to assess the effects of climate change on particle dose. The study will provide insights into potential health risks associated with air pollution exposure.

Thesis #4: In vitro exposure of pulmonary cell lines to selected air pollutants and evaluation of this exposure on the production of pro-inflammatory and other stress markers, as well on the susceptibility to common respiratory bacterial pathogens.

Thesis to be offered to MEAmb and MeMec

Thesis #1

Title: Key factors and sources influencing air quality in Portuguese urban areas

Supervision: Patrícia Baptista and Marta Almeida

Specific objectives:

- Characterize the temporal and spatial variability of air quality in selected Portuguese urban areas, focusing on daily and seasonal patterns using pollutant data from national air monitoring stations.

- Assess the influence of extreme weather events, particularly heatwaves, on atmospheric pollutant concentrations, with an emphasis on pollutant formation and dispersion processes.

- Analyze the relationship between meteorological parameters (e.g., temperature, humidity, wind speed/direction, precipitation, pressure) and air pollutant behavior to identify climatic drivers of air quality degradation.

- Explore correlations between air quality fluctuations and public health impacts, using health data related with respiratory and cardiovascular illnesses.

- Explore future air quality trends under different climate change scenarios, using reference climate models to assess potential shifts in pollutant behavior and associated health risks.

Requirements: The candidate should have strong organizational skills, be autonomous, and have an interest in scientific activities, with proficiency in statistical and data analysis tools, and preferably knowledge of atmospheric modeling.

Location: Centro de Ciências e Tecnologias Nucleares, Campus Tecnológico e Nuclear and IN+ Center for Innovation, Technology and Policy Research

Observations: This work is part of the European project MI-TRAP, which aims to evaluate the impact of transport on air quality in European cities.

Thesis #2

Title: Advancing Source Apportionment Methods for Urban Air Quality Management in Lisbon

Supervision: Marta Almeida and Tiago Faria

Specific objectives:

1 - Enhance source apportionment (SA) methods with a focus on on-line measurements, multi-time databases and particle number size distribution information.

2 - Conduct an air quality monitoring campaign in Lisbon, applying advanced SA techniques to identify major pollutant sources and their correlation with meteorological conditions.

3 - Provide scientific support to policymakers for the selection and implementation of effective air quality mitigation measures.

4 - Explore the potential impact of relevant technological developments on future air quality.

Requirements: The candidate should have strong organizational skills, be autonomous, and have an interest in scientific activities, with proficiency in statistical and data analysis tools, and preferably knowledge of atmospheric modeling.

Location: Centro de Ciências e Tecnologias Nucleares, Campus Tecnológico e Nuclear

Observations: This work is part of the European project MI-TRAP, which aims to evaluate the impact of transport on air quality in European cities.

Thesis #3

Title: Assessment of particle deposition in the human respiratory tract: Influence of urban environments and extreme air pollution events

Supervision: Vânia Martins and Marta Almeida

Specific objectives:

1 – Airborne particle sampling and monitoring in various urban microenvironments, including during extreme air pollution events (e.g., forest fires and dust intrusions from North Africa).

2 – Characterise atmospheric particle concentrations under current conditions and future scenarios.

3 – Implement the ExDoM dosimetry model to estimate the airborne particle deposition in different regions of the human respiratory tract (HRT) considering various microenvironments and scenarios.

4 – Assess the influence of factors such as particle size, concentration, and individual characteristics (e.g. gender, age, breathing type) on HRT deposition.

5 – Compare deposition patterns across different urban microenvironments and scenarios.

6 – Identify measures to mitigate the health risks associated with human exposure to air pollution.

Requirements: The candidate should have strong organisational skills, be autonomous, and have interest in scientific activities.

Location: Centro de Ciências e Tecnologias Nucleares, Campus Tecnológico e Nuclear

Observations: This work will be developed within the scope of the European project MI-TRAP and the FCT project iMPact, both investigating the role of traffic as a source of air pollution.

Thesis to be offered to MEBiol, MBMRP, MEBiom and MMicro

Thesis #4

Title: Climate Change and Air Quality: In Vitro Lung Tissue Models for Assessing Pollutant-Induced Respiratory Risks

Supervision: Tiago Fernandes and Jorge Leitão

Specific Objectives:

1- Develop an advanced in vitro lung tissue culture system to model respiratory responses to air pollutants.

2- Assess cellular and molecular responses of lung tissue to key pollutants, including oxidative stress, inflammation, and barrier dysfunction.

3- Evaluate the potential increased susceptibility of lung tissue to infections and respiratory diseases due to climate-related air quality changes.

4 - Evaluate the potential pathogenicity of selected pathogens using the tissue lung model.

5- Provide scientific insights to support public health policies and risk mitigation strategies regarding air pollution and respiratory health.

Requirements: The student must be highly motivated and committed to perform research work to achieve the scientific objectives of the work, and must have completed all curricular units prior to the initiation of the dissertation project.

Location: Stem Cell Engineering and Regenerative Medicine Research Group (SCERG-iBB) at IST-Oeiras, and Biological Sciences Research Group (BSRG) at Alameda (South tower, 6th floor).