INDAIRPOLLNET (INDOOR AIR POLLUTION NETWORK):
DRIVING INDOOR AIR QUALITY RESEARCH IN EUROPE

In developed countries, we spend 80-90% of our time indoors where we receive most of our exposure to air pollution. Despite this fact, regulation and funding for air pollution focuses on outdoors: the indoor environment is less well characterised or even recognised as a potential location for exposure to air pollution. However, air pollutant concentrations are often higher indoors than outdoors, particularly following activities such as cleaning and cooking. It is also worth noting that some of these activities can generate harmful pollutants that are commonly observed outdoors, such as particulate matter and formaldehyde. Given that outdoor air quality monitoring sites and models are currently used to assess our exposure to air pollutants with no consideration of our exposure to air pollutants indoors, we are unlikely to have an accurate understanding of our overall exposure to air pollution. The consequence of this omission is that policies that aim to reduce our exposure to air pollution may fail, as they are not addressing all, and potentially the most important, sources of exposure.

Issues around indoor air quality (IAQ) have come into sharper focus recently with the COVID-19 pandemic. Many of us are spending even more time indoors, particularly in our homes. This increased time indoors can be set against the backdrop of energy efficiency measures that are making buildings more airtight to address climate change impacts. For the reasons stated above, there is a clear need to balance energy conservation goals with satisfactory IAQ. This balance can only be achieved by gaining a fundamental understanding of the indoor environment and its relationship to outdoors through ventilation.

Aim

The aim of INDAIRPOLLNET (INDoor AIR POLLution NETwork) is to improve our understanding of the conditions and processes that cause high concentrations of indoor air pollutants. It aims to:

- significantly advance the field of indoor air pollution science
- to train a new generation of Early Career Investigators (ECIs)
- to highlight future research areas and
- to bridge the gap between research and business to identify appropriate mitigation strategies that optimise IAQ

We will use this network to design the optimal indoor air campaign that provides maximum scientific impact, but is also of relevance for the types of buildings in which people, live, work and play.

INDAIRPOLLNET is a European COST (Cooperation in Science and Technology) Action (https://www.cost.eu/). These are research networks that enable collaboration among scientists across Europe (and beyond). They aim to give impetus to research advancements and innovation. COST Actions are bottom up, allowing researchers to create a network based on their own research interests in any science field and are highly interdisciplinary and inclusive. COST funding intends to complement national research funds, as they are exclusively dedicated to cover collaboration activities, such as workshops, conferences, working group meetings, training schools, short-term scientific missions, and dissemination and communication activities.

INDAIRPOLLNET originally had around 50 proposers when it started in September 2018, but now has more than 200 members. We are currently around 2.5 years into our 4-year programme. The current spread of members is shown in figure 1 with a photograph from our start-up meeting shown in figure 2.

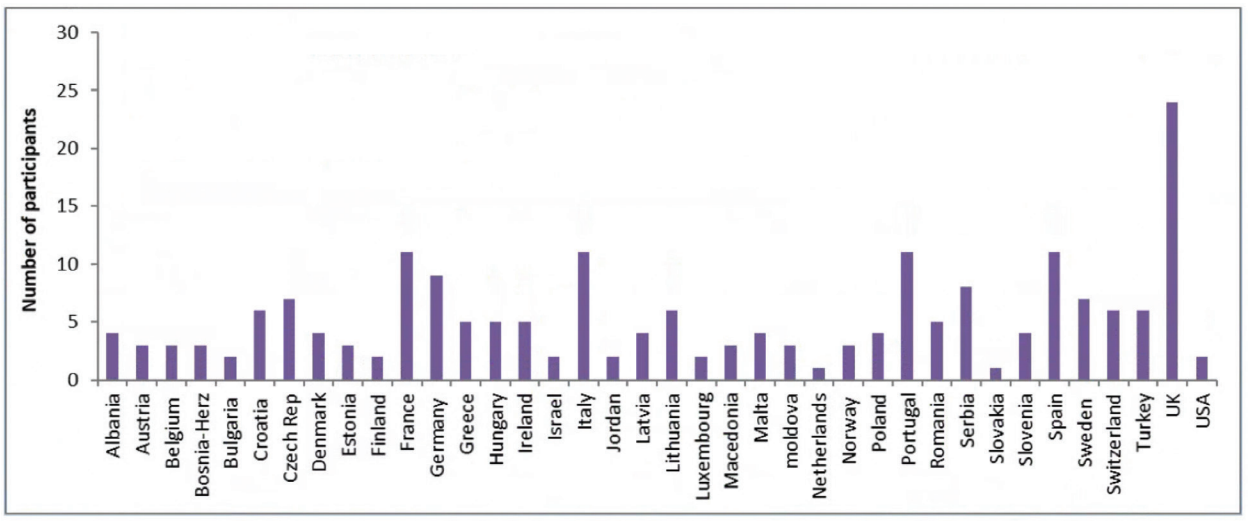


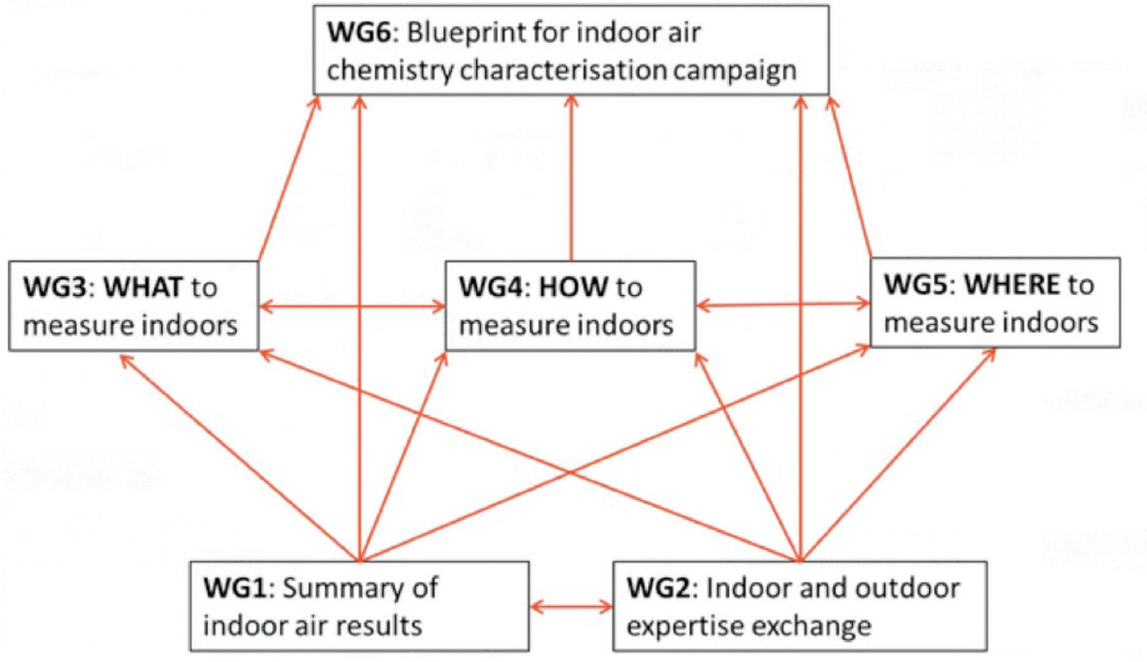
Figure 1: Spread of members of INDAIRPOLLNET across different European countries, as well as some other collaborating partners from Jordan, Israel and the US.

We have experts in chemistry, biology, standardisation, household energy, particulate matter characterisation, toxicology, exposure assessment, air cleaning, building materials (including those manufactured specifically to improve IAQ such as bio-based composites and green materials), building physics and engineering (including ventilation and energy) and building design. We are keen to facilitate knowledge exchange between indoor and outdoor air chemists (e.g. for measurement techniques, field campaign organisation and analysis of results) where relevant, but with consideration of related and relevant disciplines (e.g. building physics, design and operation) to design indoor field studies that are relevant for a wide range of buildings. Our findings will be disseminated directly to relevant stakeholders such as architects, building engineers, building managers, property developers, urban planners and instrument manufacturers. Indeed, such stakeholders are active members of our working groups, enabling our results to have relevance and reach for as wide a range of stakeholders as possible.

Figure 2: Meeting attendees for our start-up meeting in York in December 2018.

Workplan

Activities have been divided into 6 Working Groups (WGs) and will culminate in a final workshop to define the optimal indoor air chemical characterisation campaign (figure 3). The first stage (September 2018-August 2019) summarised existing model and experimental results indoors (WG1) and outdoors (WG2) to establish what is known and what remains unknown. WGs1-2 fed into WG3 (September 2019-June 2021) which covers 'What' to measure indoors, whilst WGs1-3 will feed into WG4 (September 2019-August 2021), which addresses 'How' to measure indoors. WGs1-4 will inform WG5 (September 2019-August 2021), which addresses 'Where' to make indoor measurements. WG6 will provide the blueprint for the optimal indoor air measurement campaign, with the results presented in the final workshop in summer 2022.



Results

WG1 provided the background for the future work, aiming for a better understanding of indoor air chemistry and to improve its representation within modelling. We summarised the relatively recent literature to be able to define chemical species that require attention in future measurements and modelling of indoor air chemistry. The aim was to build on and advance the most recent knowledge about what occurs in indoor air. The task was divided into the following subtasks/topics:

- Chemical transformations (gas phase, surface chemistry, secondary organic aerosols, hydrolysis, oxidation)
- Indoor air chemistry related to the following sources:
  - o Buildings (building materials, HVAC systems)
  - o Occupants (human emissions, bioeffluents, clothes and their chemical transformations)
  - o Occupant behaviour/household products (cleaning agents, electronic equipment, cooking, smoking, appliances, furnishing)
  - o Microbial activity
  - o Role of particles
  - o Source apportionment of select chemical and particulate compounds
- Modelling indoor air chemistry (identify existing models, compare their complexity, usefulness, weaknesses, experimental validation)

We used peer-reviewed literature, primarily review articles and original papers published in the past 10 years (January 2009 – December 2018). Non-peer-reviewed literature was excluded, except government and reports published by authoritative organisations such as WHO, EPA, UN. Older landmark studies were included, especially when a particular field is not well covered in recent literature. We focused on indoor air chemistry, not necessarily indoor air chemicals alone. Exposure studies (studies reporting air and dust concentrations, exposure pathways, intake, metabolism, elimination and health effects) were only included to a limited extent. The literature on particulate pollution is overwhelming. We focused on the aspects most relevant for indoor chemistry and included this information in the respective sub-sections with the focus on the chemical mechanisms for indoor particulate formation. The full report for WG1 as well as a short editorial in the Indoor Air journal can be found here: https://indairpollnet.eu/publications/.

WG2 aimed to summarise information from outdoor air chemistry studies that could be relevant for the indoor air chemistry community. Outdoor air pollution measurements and models have been made for a considerably longer period of time than for indoors, so we wanted to maximise that knowledge. The task of this Working Group was divided into the following subtasks:

- Outdoor field campaigns
- Outdoor models
- Simulation chamber studies
- Linkage between WG1 and WG2

The initial purpose was to review recent literature using Web-of-Science or other platforms and to focus on peer-reviewed articles, mainly review articles published during the past 10 years (2009 – 2018), following the procedure for WG1, for consistency. However, the enormous amount of literature and the scope of WG2 prevented us from an exhaustive literature review within each subtask. The subtask leaders had the freedom to define the search procedures, search terms or other ways to select relevant literature or other information to proceed with their subtasks. The final report can be found here: https://indairpollnet.eu/publications/.

WGs3-5 will be completed later this year, at which point our findings will be available for the community on the same web site. WG3 will provide a ranked list of species that we feel the indoor air community should focus on in the future. These will be ranked based on several metrics, including potential health effects, chemical reactivity and propensity to make ultrafine particles indoors. This information would prove useful for those looking to develop relevant instrumentation for measurements of IAQ in the future.

Author Contact Details

Nicola Carslaw, University of York • Email: nicola.carslaw@york.ac.uk • **Web: https://indairpollnet.eu/**