

Air quality: the impacts of UK university research

Ben Williams shows that UK universities make a vital contribution to research into the causes, effects and management of air pollution.

Air pollution is the biggest environmental risk facing humanity in modern times. According to the World Health Organisation (WHO), 7 million people died as a result of exposure to air pollution worldwide in 2012, equivalent to one in every eight recorded. The greatest burden was carried by countries in the South-East Asian and Western Pacific regions, where 3.3 million deaths were linked to indoor air pollution and a further 2.6 million linked to outdoor air pollution¹. In Europe, air pollution has contributed to approximately 400,000 deaths a year², and in the UK both PM_{2.5} and NO₂ have been associated with more than 50,000 premature deaths a year.

Our ecosystems are also damaged by air pollution through mechanisms such as eutrophication, and it has a significant impact on crop yields annually. In financial terms, air pollution is thought to cost the UK £15 billion a year³.

Globally, the main impact from indoor air pollution is from burning solid fuel for cooking and heating. From a UK perspective, the biggest impact is from vehicle emissions, something that is exacerbated in cities with high population densities and therefore high vehicle numbers. Increasing urbanisation will expose more people to air pollution. Research and innovation in the field of air quality is therefore of the utmost importance for minimising the impact of air pollution on the health of citizens.

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The air quality impact case studies summarised here were obtained by performing a search for “air quality” using the Higher Education Funding Council for England (HEFCE) online database⁴ of the 2014 Research Excellence Framework (REF). Of the 57 results, many merely refer to air quality, so the actual number of case studies dedicated to air quality is about 40.

The research undertaken beneath the umbrella of air quality is wide and varied; key topics include:

- Forecasting air pollution and understanding its causes;
- The impact of various pollutants on public health; and
- The development of monitoring tools.

The impact of this research manifests itself in various ways, for example:

- By informing policy development at national and international levels;
- By assisting in the development of regulations and strategies for air quality management; and
- Through the development of technologies and methods for reducing and mitigating the risk of harm caused by air pollution.

IMPACT ON POLICY

Impact is often realised by working closely with policy-makers, targeted funding mechanisms, publications and membership of the relevant committees. UK research has influenced changes in policy both at home and internationally, with institutions such as the Environment Agency (EA), the European Commission (EC), the US Environmental Protection Agency (EPA) and the International Civil Aviation Organization (ICAO) using this body of work both to help set regulations and put guidance in place as well as helping to make sure they are adhered to.

Evidence-based policies, underpinned by rigorous scientific research and cutting-edge tools and methodologies, are crucial. The research in the field of air quality is as varied as its impact on policy, which ranges from informing traffic regulations and control (e.g. the London congestion charge and low emission zones), emission limits and building regulations, to providing specific air quality management procedures for local authorities and methods for restoring pollution-affected landscapes.

PUBLIC HEALTH

The efforts to reduce emissions are largely motivated by the need to reduce the negative health impacts of air pollution. One of the clearest and more immediate impacts on public health described in these case studies is the ability to warn the public of high-risk pollution events, due to the development of improved forecasting models. These allow vulnerable populations to take the necessary precautions when the air quality is particularly bad in a certain area. A number of case studies have demonstrated advances in remote sensing and modelling of meteorology and pollutants for the Met Office and for local organisations such as the fire brigade and other public agencies.

Other examples of emissions reduction include the development of efficient industrial air cleaners, and hybrid diesel-electric and electric-hydrogen vehicles.

AIR QUALITY MANAGEMENT

Air pollution is managed at an international and national level through the regulation of pollutant emissions and often more visibly at a local level through the introduction of Air Quality Management Areas and the development of air quality action plans (exemplar air



▲ **Figure 1. The percentages of case studies assigned the Summary Impact Type 'environmental', and which were submitted under the Earth systems and environmental science UoA. (Source: REF2014 impact case study database; search term: "Air quality").**



▲ **Figure 2. In many cities vehicle emissions are a major air quality and public health problem. (© Anizza | Dreamstime)**

quality action plans can be found on the Department for Environment, Food and Rural Affairs (Defra) website⁵). Relatively few case studies focused specifically on air quality management. One example was a case study that contributed to the improvement in local air quality management systems within the UK, Europe, Asia and South America by enabling the understanding of the spatial extent of air pollution. Research into how air pollution is managed at a local level identified the need for well-resourced and well-trained air quality specialists, which lead to the establishment of a professional body dedicated to the professional development of the air quality workforce (the Institute of Air Quality Management; IAQM).

INDOOR AIR POLLUTION

Indoor air pollution has a more significant impact on health globally, in spite of not being bound by the same legislation as outdoor air pollution in many places. For example, air pollution has been linked with heart disease and stroke, chronic obstructive pulmonary disease and acute lower respiratory infections, and reduced lung function in children⁶. It is considered that those households in which

solid fuel is used for heating and cooking would find it difficult both practically and economically even when more sophisticated (and often cleaner) fuels are available⁷. Some case studies submitted to REF 2014 have demonstrated improvements to air conditioning units, whilst others have demonstrated building design improvements as a means of improving indoor air quality.

IMPACTS OF NATURAL SOURCES OF AIR POLLUTION

In the wake of the 2010 eruption of Eyjafjallajökull in Iceland, a number of case studies focused on the impact of volcanic emissions on the aviation industry and how such impacts may be mitigated in future. One project resulted in the development of a system for identifying safe flying areas (based on pollutant concentrations) during an eruption, avoiding the need to ground all aircraft and thereby saving the industry millions of pounds.

Other impacts on health from natural sources of air pollution include a more detailed understanding of the relationship between radon and lung cancer leading to changes in building regulations that have reduced exposure to the radioactive gas in new homes.

BOX 1: AIR QUALITY MANAGEMENT¹⁰

Improving the management of air quality

The Air Quality Management Resource Centre (AQMRC) at the University of the West of England (UWE) operates at the interface of air quality science and policy. This case study demonstrates how evidence from research by this group "has enabled UK local and national governments and international governments (South Africa, Nigeria) to enhance their processes and procedures for managing air quality".

This case study outlines how research from the AQMRC has contributed significantly to a wider understanding politically and amongst the public of the risks posed by air pollution and promoted engagement in its management at the local level. In the UK, UWE research has informed official guidance issued to Local Authorities by UK governments, and researchers have advised devolved national and London administrations on the development of guidance, legislation and regulation. In recognition of the importance of a well-trained and resourced workforce, the AQMRC also co-founded the Institute of Air Quality Management, which is now acknowledged as the air quality professional body.

As well as contributing significantly to a review of the Local Air Quality Management process by the UK government's in-house policy consultants in 2010, this case study also shows how research from UWE has been recognised internationally. UWE findings were particularly influential in the development of a national framework in South Africa and practices adopted by national agencies in Nigeria.

WHAT CAN WE LEARN?

The battle to improve both indoor and outdoor air quality requires the focus of a quartet of research avenues, namely:

- Technological advances (e.g. improved emissions technologies);
- Monitoring and sensing developments (i.e. improved particulate and gas analysis techniques);



▲ **Figure 3. Eyjafjallajökull volcano erupting in Iceland. In the wake of this eruption several case studies focused on the impact of volcanic emissions on aviation.** (© Anders Peter Amsnæs | Fotolia)

- Improved air quality management plans and policies (e.g. local air quality management); and
- Communication.

To make significant impacts, not just on policy, but on the quality of our air, it will be vital to continue communicating with both policy-makers and the general public. In order to ensure governments and businesses pay attention it is becoming increasingly necessary for the impact of air quality research to demonstrate value in terms of savings and generating revenue.

Additionally, there are synergies between the aims of air pollution and, for example, sustainable development, where a reduction in energy use would lead to a reduction in pollutant emissions, or when strategic town planning reduces the need for commuting and thus reduces the number of vehicle journeys.

WHAT IMPACT IS NOT CAPTURED BY REF 2014?

Behavioural change is key when it comes to addressing the challenge of air pollution and yet almost none of the case studies submitted to REF 2014 described research that sought

to change the actions and attitudes of individuals. There may be plenty of research in this area, but the impact may be too difficult to measure for the purposes of REF 2014, or perhaps human behaviour is too difficult to influence on any meaningful scale over a relatively short space of time.

However, there are signs among these case studies that public engagement is increasingly on the agenda for researchers in this field – an impact case study described a community mapping project that involved thousands of citizens in mapping air pollution across their communities. Whether projects like this have any lasting impact on behaviours or contribute to a reduction in air pollution remains to be seen.

HOW CAN WE IMPROVE THE IMPACT OF OUR RESEARCH?

There are significant opportunities to boost the potential impact from UK researchers through greater engagement with institutions in countries experiencing the greatest effects of air pollution, most notably China, India and other south-east Asian nations. Best practice developed within the UK and Europe can be adapted and applied to these areas.

BOX 2: PARTICIPATORY MAPPING¹¹

Participatory GIS in action: new social enterprise Mapping for Change

In 2009, the social enterprise Mapping for Change (MFC) was established by researchers from University College London (UCL) in collaboration with partners from the London 21 Sustainability Network to make use of participatory mapping tools and software developed at UCL and associated knowledge. This case study concerns the impact this research has had through this social enterprise.

MFC projects help communities to use mapping and geographical technologies to collect, analyse and visualise information about their life and environment, and then develop action plans on this basis. Projects are developed through co-design with communities themselves. Since 2009 MFC has delivered over 30 projects in many communities with a range of impacts, including the implementation new environmental monitoring operations by several local authorities, and stimulated debate about the issues of noise and air pollution.

Work on air pollution has included a participatory pollution mapping exercise at seven locations around London, which has helped to demonstrate where emissions are above EU guidelines, and promoted action to protect residents.

BOX 3: RISK ASSESSMENT METHODS¹²

Development of risk assessment methods for the impacts of ground level ozone (O₃) on ecosystems to inform European atmospheric emission reduction strategies.

By the early 1990s, a large body of experimental data existed which demonstrated the adverse impacts of O₃ on crops, forests and grassland ecosystems. Lisa Emberson at the University of York has been researching the development and application of risk assessment methodologies for this pollutant, and this case study concerns the impacts of this work.

This programme of research has developed new risk assessment methods, based on knowledge of atmospheric exchange processes and plant eco-physiology, which assess O₃ uptake and related damage using a novel 'Critical Levels' classification system based on a stomatal flux model (which is based on O₃ uptake via the leaf pores). These methods are being used "by 26 parties (member states) who have signed and ratified the United Nations Economic Commission for Europe (UNECE) Gothenburg Protocol established under the Convention on Long Range Transboundary Air Pollution (LRTAP)". In this way, this research has led to tighter controls on emissions of ozone across Europe, benefiting crop and forest productivity and grassland species composition.

Closer collaboration between researchers and vehicle manufacturers could have multiple benefits. Some, including the development and improvement of alternative fuels and their efficiency are presented in these case studies. However, both strategic and technological opportunities exist, including collaboration on improving the fuel efficiency of cars and the transition of businesses from being dependent on fossil fuels to being pioneers in the use of renewable energy sources.

Because of the significant impact air pollution has on the human population and on the global ecosystem, the air

quality research community within the UK must continue to grow and develop. Despite the relatively small pool of researchers, the outputs presented here have had considerable reach globally and on the basis of current opportunities presented by funders such as the Natural Environment Research Council (NERC)⁸, the Newton Fund and the Wellcome Trust⁹ it is likely that a greater number of air quality impact case studies will be submitted to future REF exercises. **ES**

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