



UNIVERSITY OF
BIRMINGHAM



ENVIRONMENTAL SCIENCES

Our research addresses the most significant challenges facing humanity, from physical and mental health implications of air, water and soil pollution in an increasingly urbanised world, to tipping points for ecosystem responses to multiple stressors, and the genetic basis of ecosystem resilience to climate change. The interdisciplinary insight we provide for policy makers, industry and the public demonstrates that **healthy environments are essential for healthy societies**.

We have internationally leading expertise in atmospheric and water sciences, urban environmental systems, environmental nanoscience, biodiversity, forest research, agriculture and food security, and 'omics technologies (genomics, proteomics and metabolomics).

Research foci include managing health and wellbeing in increasingly urbanised societies, and understanding impacts of intensive farming and deforestation on ecosystem function.

Our research takes place within a global context. For example, research on adaption of protocols for safety assessment of nanomaterials is undertaken in conjunction with the Organisation for Economic Cooperation and Development, the International Standardisation Organisation, the European Chemicals Agency and equivalent organisations around the world.

Our research spans the science-policy interface and is carried out in close collaboration with external stakeholders, including national and local government, the European Commission and its Joint Research Centres, WHO, UNESCO, European Food Safety Authority and others.

Background

The unprecedented pace of human impact on the planet has led to the classification of a new geological epoch: the Anthropocene. Humanity's growing ecological footprint is altering our planet's land cover, rivers and oceans, climate system, biogeochemical cycles, and ecosystems functioning.

Our research explores anthropogenic effects on ecosystems across rapid, seasonal, decadal and evolutionary timescales.

The importance of the environment to humans goes beyond food security, clean air, water, and energy: our mental and physical health, wellbeing and economic prosperity are interlinked with ecosystem diversity and

resilience. However, the complex balance of food-webs and ecosystem functions are close to irreversible tipping points. Our cross-disciplinary approaches utilising lab, mesocosm and field scale experiments are defining ecosystem health indicators for measurement, monitoring, and remediation.

The scale of global pollution is staggering: 92% of the premature pollution-related deaths in 2015 occurred in low and middle income countries. Our research addresses a broad spectrum of legacy and emerging pollutants, including exhaust emissions, persistent organic pollutants, nanomaterials and microplastics, and the >100,000 chemicals in the environment, less than 10% of which have been assessed for their human and environmental safety.

**9.19 MILLION
PREMATURE DEATHS IN
2015 (16% OF GLOBAL TOTAL)
WERE POLLUTION-RELATED,
THREE TIMES MORE THAN
AIDS, TUBERCULOSIS
AND MALARIA COMBINED.**

The Evidence

Our research pipelines span fundamental laboratory research to real world consequences, linking our molecular capabilities and outstanding facilities for mesocosm and field measurements, including utilisation of drones, earth observation and numerical modelling, propagating understanding of wider societal impacts through to policy change. Our Birmingham Institute of Forest Research Free-Air Carbon Dioxide Enrichment (BIFoR-FACE) experiment is a unique opportunity to explore the impacts of climate change on forest ecosystem functioning.

We have a unique range of pure and applied **meteorology and climate** research, including significant knowledge transfer to the international meteorological marketplace. Modelling is a particular strength; from small scale street canyon turbulence models to global circulation models. These models are used to quantify the impact of weather and climate on the economy, society and the built environment. We also undertake numerical modelling of the impact of environmental change on natural and managed ecosystems, including forests and crop yields. We are home to the **Birmingham Urban Climate Laboratory**, a unique network of over 100 air temperature sensors and 30 weather stations across the city.

Urban ecology is another strong theme in our research, focusing on understanding the dynamics and biodiversity of urban habitats, their resilience to disturbance, and how blue (water management) and green (e.g. green-walls for air pollution reduction, green spaces for flood management etc.) infrastructures be designed to deliver societal and planetary wellbeing. Emerging research is parameterising the links between healthy environments and physical and mental wellbeing, through physiological indicators of happiness and economic indicators such as productivity.

Our internationally leading **Water Sciences** research addresses hydrohazards (floods and droughts), resilience of aquatic ecosystems to human disturbance, and management of water resources in a changing environment.

Innovative collaborations allow us to play leading roles in **global food security**, where our plant science expertise is applied to conservation of agriculturally significant species, and a diverse range of modern molecular and genomics approaches are used to understand species resilience to climate change and adaption to drought, flooding, and elevated CO₂. Emerging areas include the potential for nanomaterials to enhance agritech, as pesticides, carriers for fertilisers and nutrients, or modifiers of soil quality or plant calorific value.

Keystone species occupy a critical place in a food-chain and are sensitive to environmental stressors such as pollutants, thus acting as early indicators of problems. The water flea, *Daphnia*, is an important example, widely used for assessment of the toxicity of chemicals and food chain signalling. Expertise in ***Daphnia* biology and genetics** is being applied to develop new techniques for measuring environmental stress responses, adaption and resilience, to both pollution and climate change.

Key Projects

AIR POLLUTION AND HUMAN HEALTH

We have internationally recognised research into atmospheric composition, using approaches ranging from novel field instrumentation, through simulation chamber and laboratory studies, to personal exposure measurements and biological markers. Our research spans understanding of natural and anthropogenic emissions, atmospheric dispersion and transport, the chemical and physical transformations of atmospheric constituents, and the effects of air pollution and atmospheric chemistry upon human health, terrestrial and marine ecosystems. We currently lead NERC/MRC-funded projects investigating the sources and impacts of air pollution in China, India and Africa, supporting reduction of air pollution-related deaths in Beijing, Delhi, Nairobi and other megacities.

MAPPING THE CHEMOSPHERE

Just as the atmosphere describes the gaseous envelope surrounding the earth, the term chemosphere is used to describe the set of chemicals we are exposed to in our daily lives, through our food, water and air. Mapping the Chemosphere will revolutionise chemicals testing, moving it from a painstakingly slow chemical-by-chemical approach to a preventative high-throughput 'omics-based screening approach, empowering individuals to understand the chemicals they are exposed to in their local environments. The resulting understanding will facilitate innovative regulatory, business, and public efforts to safeguard health. Returns on investment are expected to be rapid and substantial, akin to the 178:1 return achieved from transforming health care by mapping the human genome.

The future

Building on Birmingham's legacy as the birthplace of the industrial revolution, we are launching an Environmental Sciences Innovation Hub. Our goal is to be the primary partner for innovative companies and disruptive technology developers across all areas of environmental science and environmental care services, offering opportunities for companies to spin-in, spin-out, and to embed their research staff into our facilities. We work with a wide portfolio of companies, from high-end instrument developers to SMEs developing environmental sensor technologies or providing data management solutions to underpin chemicals regulation and environmental risk assessment.

Our research is designed to accelerate the translation of interdisciplinary science into improved regulatory frameworks (e.g. REACH, Water Framework Directive) that promote environmental and human health whilst stimulating economic activity in a global market that increasingly values protection of the environment and sustainability.

Our global leadership is driving a culture change towards responsible innovation, environmental stewardship and environmental democracy.

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