University of Reading

IMPACT CASE STUDY

Water quality

Modelling nutrient pollution to protect our waters

The accumulation of nutrients exported into water from land and atmospheric sources generates a variety of adverse impacts, leading to the loss of biodiversity and ecosystem services, and compromising water security both nationally and internationally. Research at Reading has enabled the development of modelling tools to simulate nutrient flux in complex landscapes in response to climate and land-use change. Work with end users has developed these modelling tools so that they support the integrated catchment management needs of Government departments and agencies, both in the UK and internationally.

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Research

The UN now rates coastal nutrient pollution as one of the greatest current threats to the global environment. Understanding the movement of nutrients and sediment through landscapes and into water bodies enables us to determine the physical, chemical and biological quality of those waters. These adverse impacts include the nutrient enrichment of waters, also known as 'eutrophication'.

The damage costs of freshwater eutrophication in England and Wales have been estimated in the scientific literature at $105-160 million per year, with the policy response costs amounting to a further $77 million per year in 2003. As a result, a raft of international conventions and policies, to which the UK is a signatory, include the mandatory requirement to bring this problem under control. This presents both a significant research and environmental management challenge, requiring effective stakeholder engagement and policy development properly underpinned by a holistic understanding of the scientific evidence.

The provision of robust scenario testing capabilities are essential if Government is to be able to assess the likely impact of policy and mitigation measures on the quality and health of the waters under its jurisdiction. Similarly, business planning within the food and water sectors requires a sound understanding of the likely impact of differing business models and propositions on the environment, which can be best supported through the availability of modelling tools underpinned by sound scientific evidence.

The Aquatic Environments Research Centre at the University of Reading was founded in 1995 to investigate catchment biogeochemical cycling. The research of the Centre has improved our understanding of the key environmental variables controlling nutrient and sediment flux within complex landscapes. Another activity has been to collect high resolution water, soil and air quality data, which has supported the development and testing of biogeochemical models at the catchment scale. These activities have enabled the development of modelling tools to simulate nutrient flux in complex landscapes in response to climate and land use change.

The modelling tools developed as part of this research include the National Export Coefficient Modelling Framework and the Integrated Catchment Model (INCA). The former provides a robust and reliable approach for identifying the sources of nutrients within a system, and in helping to target mitigation measures in catchment management programmes. The model is very simple to implement and as a result is widely used in both the UK and internationally.

The INCA modelling suite is more complex, operating on much shorter timescales and generating daily simulations of nutrient fluxes in river systems, as well as providing information on sediment transport and streamflow. INCA enables the modelling of net nutrient flux from headwater catchments to downstream reaches and the coastal zone. It has been used by environmental agencies and research groups across the UK and Europe as a tool to support integrated catchment management.

Impact

The modelling tools produced through this research, and the scientific evidence acquired, have been used alongside comparable research by others to provide an ensemble of evidence for development and testing of environmental management policy and practice by Defra, the Environment Agency (EA) and the statutory UK conservation agencies.

The National Export Coefficient Modelling approach has been used by the EA to characterise the baseline nutrient status of UK waters, and the extent to which they are at risk of failing to achieve Good Ecological Status under the EU Water Framework Directive. It was also used to generate the UK Nitrogen budget submitted to the Task Force for Reactive Nitrogen and to the Expert Panel on Nitrogen Budgets of UNECE (UN Economic Commission for Europe) to support the International Convention on Long-range Transboundary Air Pollution negotiations on the revision of its Gothenburg multi-pollutant/multi-effect protocol (the Gothenburg Protocol), specifically on Annex IX which aims to control ammonia emissions from agriculture.

The Method Statement for Nitrate Vulnerable Zone review report produced by the EA in 2012 demonstrates the use and impact of this work, and outlines the process, methods and evidence used for identifying waters which are eutrophic or may become eutrophic if preventative action is not taken. The report uses evidence from this research which has shown that nitrogen is a limiting factor controlling the degree of eutrophication in standing waters. It also uses the National Export Coefficient Model as part of the methodological toolkit for compliance with the EU Nitrates Directive. The 2012 Ecosystem Services Indicators Methodology report by Natural England on ecosystem services indicators recommends that: 'subject to the availability of central funds, the contribution of habitat extent to water quality should be established through application of a series of nutrient export coefficients derived from the literature', citing the research described within this case study on this approach.

Further impact that this research has had can be demonstrated by its inclusion in five reports produced by Defra (UK National Ecosystem Assessment, 2011), Natural England (Environmental Impacts of Land Management, 2009), the Scottish Government (Initial evaluation of effectiveness of measures to mitigate diffuse rural pollution, 2009), Teagasc (Submission on draft WFD River Basin District Management Plans, 2009) and the Land Use Policy Group (A review of environmental benefits supplied by agri-environment schemes, 2008). The reports used the outcomes from a Commissioned Advice Note which was prepared for Defra in 2007, using the National Export Coefficient Model to inform the development of integrated catchment management strategies to reduce nutrient loading on waters in England, Scotland, Ireland and Wales and thereby comply with the EU Water Framework Directive.

The INCA modelling suite has been used to inform the implementation of the EU Water Framework Directive in the light of projected climate change under three EU-funded programmes: EU-INCA (Integrated Nitrogen Model for European Catchments), EUROLIMPACS (Assessing the impacts of climate change on European freshwaters) and EU REFRESH (Adaptive strategies to mitigate the impacts of climate change on European freshwater ecosystems). Specific evidence of uptake and impact of this work in the UK is provided in the EA's 2009 River Basin Management Plan for the Thames River Basin District. This uses the INCA modelling suite to provide evidence that nutrients released from agriculture or from sewage treatment works in future could be less diluted under a changing climate, due to reduced flows in summer, with the reduced flows and higher concentrations of nutrients promoting algal growth and the dieback of important aquatic plant species in these reaches.

This research and these modelling applications have directly influenced Government policy in relation to land use and management. The ultimate impact of this work and the application of these modelling tools by these agencies along with the research of others has been the development of the EU Water Framework Directive which requires each EU member state to assess the quality of its waters and implement river basin management plans to reduce pollution of these waters to ensure that they support 'good ecological status'.

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NATURAL ENVIRONMENT RESEARCH COUNCIL

For more information, please contact:

Professor Penny Johnes

Geography and Environmental Science
University of Reading

p.j.johnes@reading.ac.uk

www.reading.ac.uk/meteorology

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