The UK is failing to achieve sufficient water quality. With improvements in sewage treatment technology, pollution generated by agriculture has become more significant. High levels of agricultural fertilisers entering water systems are a leading cause of eutrophication that lowers water quality.

The Source Apportionment-Geographical Information System (SAGIS) Water Quality model has allowed UK regulators to apply the ‘polluter pays’ principle. Now, all significant polluters can be identified at waterbody scale across the entire country. This model has revolutionised how the UK regulates, plans and invests in improving water quality and has informed a £4 billion investment between 2015-20 to reduce chemical pollution entering UK rivers, via measures to further treat sewage effluent and to encourage farmers to improve water run off from land.

Identifying and quantifying sources of pollution

“...No other country in the world has a chemical source apportionment model of equivalent range of sources, chemicals or scale to the Source Apportionment-Geographical Information System (SAGIS) Water Quality model.”

Summary

The UK is failing to achieve sufficient water quality. With improvements in sewage treatment technology, pollution generated by agriculture has become more significant. High levels of agricultural fertilisers entering water systems are a leading cause of eutrophication that lowers water quality.

The Source Apportionment-Geographical Information System (SAGIS) Water Quality model has allowed UK regulators to apply the ‘polluter pays’ principle. Now, all significant polluters can be identified at waterbody scale across the entire country. This model has revolutionised how the UK regulates, plans and invests in improving water quality and has informed a £4 billion investment between 2015-20 to reduce chemical pollution entering UK rivers, via measures to further treat sewage effluent and to encourage farmers to improve water run off from land.
The UK's freshwater ecosystems provide many benefits, from carbon sequestration to clean water provision, yet human activity is negatively affecting freshwater environments in many places. Just 14% of English rivers assessed under the WFD achieved good ecological status. Two key reasons behind this shortfall are fragmented policy approaches and a failure to quantify and address sources of pollution, such as agricultural runoff. The WFD's monitoring framework provided a good understanding to date of the status of large rivers and waterbodies in the UK. Despite the inter-connectedness of freshwater systems, policy has generally ignored small water bodies. It is now recognised that all components of a 'catchment' (watersheds or drainage basins), need to be included in the evidence base and Defra has responded by establishing an expert working group on small water bodies to bring together research, policy and stakeholder organisations in a 'catchment systems approach'.

Quantifying sources of pollution is more challenging. Water pollution in the UK has historically been attributed to sewage and heavy industry. The UK has made progress in holding the water industry accountable for sewage and effluent discharges, but it has become more pressing to tackle pollution from agriculture including runoff from fields and farm infrastructure. In response to this shift in the distribution of pollution entering UK waters, the UK Government enacted a 'fair share' policy within the "polluter pays" philosophy set by the WFD, ensuring that those who pollute bear the costs of mitigating the effects of that pollution.

Context
The UK's freshwater ecosystems provide many benefits, from carbon sequestration to clean water provision, yet human activity is negatively affecting freshwater environments in many places. Just 14% of English rivers assessed under the WFD achieved good ecological status. Two key reasons behind this shortfall are fragmented policy approaches and a failure to quantify and address sources of pollution, such as agricultural runoff. The WFD’s monitoring framework provided a good understanding to date of the status of large rivers and waterbodies in the UK. Despite the inter-connectedness of freshwater systems, policy has generally ignored small water bodies. It is now recognised that all components of a ‘catchment’ (watersheds or drainage basins), need to be included in the evidence base and Defra has responded by establishing an expert working group on small water bodies to bring together research, policy and stakeholder organisations in a ‘catchment systems approach’.

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Key points
- Sewage effluent and agriculture are negatively affecting freshwater ecosystems
- Identifying and quantifying sources of pollution in water systems is challenging but necessary now the UK Government has enacted a ‘fair share’ policy within the “polluter pays” philosophy;
- The SAGIS model allows UK regulators to apply the EU Water Framework Directive (WFD) ‘polluter pays’ principle as sources of pollution can now be reliably identified and apportioned within the UK river system;
- A systems approach is needed to reduce pressures on freshwater ecosystems through integration with the delivery of other environmental objectives;
- An effective monitoring programme of both farms and the wider environment is required to provide a baseline to measure compliance against environmental regulations;
- A catchment oriented, integrated water management system in the UK is needed with a polycentric style of governance.

Between 2015 and 2020, SAGIS modelling was used to justify the following investments to improve water quality by reducing the amount of phosphorus entering rivers:

- £2.3bn of water industry infrastructure improvements including upgrades to sewage treatment works to meet tighter phosphorus permit conditions;
- £0.4bn investment in agriculture through the Countryside Stewardship Scheme to better manage runoff from farm infrastructure (e.g., buffer strips adjacent to watercourses, fencing off rivers from livestock etc.), and
- £50m in farmer match-funding via Catchment Sensitive Farming including advice to farmers on fertiliser management and use.

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Just 14% of English rivers assessed under the WFD achieved good ecological status.
Prior to the development of SAGIS, the financial burden of water quality improvements in the UK fell largely onto the water industry. Regulators can now reliably identify and apportion the sources of pollution (particularly phosphate) between agricultural and sewage effluent sources within the UK river system. The continued development of the SAGIS model in the last five years has refined outputs, provided decision support tools, improved forecasting accuracy and enriched existing databases, improving the precision and usability required to justify an increasing amount of investment made by the water industry (and agriculture) through future cycles of the WFD (2021-2027).

The SAGIS model was used during the second cycle of the Water Framework Directive (2015-2021) to identify sites of sewage works upgrades as well as for farm interventions such as the improved management of slurry, silage, on-farm surface water runoff and stock control to prevent fertilisers and manures polluting rivers. It has also supported efforts to provide grants to relevant farmers, to ensure the desired water quality improvements are achieved.

Using an accurate, predictive model such as SAGIS allows researchers and policymakers to predict the future impact of investments to improve water quality, so that targeted and cost-effective solutions can be implemented.

Impact

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### Addressing the issue

Research led by the University of Plymouth’s Professor Sean Comber identified and quantified pollution sources through the (SAGIS) Water Quality model. This model allows UK regulators to apply the WFD’s ‘polluter pays’ principle. Now all significant polluters can be identified at waterbody scale across the entire country and their contribution to the issue quantified. SAGIS has enabled the regulators to target the significant sources of pollution and demand billions of pounds of investment to upgrade sewage works. Ongoing research has driven the development of the model to better predict nutrient sources and chemical fate in rivers, allowing regulators to confidently predict the impact of planned investment to improve water quality.

### Impact

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### Percentage of water bodies impacted by each sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage of water bodies impacted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>45%</td>
</tr>
<tr>
<td>Industry</td>
<td>6%</td>
</tr>
<tr>
<td>Mining and quarrying</td>
<td>3%</td>
</tr>
<tr>
<td>Navigation</td>
<td>2%</td>
</tr>
<tr>
<td>Urban and transport</td>
<td>18%</td>
</tr>
<tr>
<td>Water industry</td>
<td>44%</td>
</tr>
<tr>
<td>Local and central government</td>
<td>14%</td>
</tr>
<tr>
<td>Domestic and general public</td>
<td>8%</td>
</tr>
<tr>
<td>Recreation</td>
<td>3%</td>
</tr>
<tr>
<td>Waste treatment and disposal</td>
<td>0.3%</td>
</tr>
<tr>
<td>No sector responsible</td>
<td>23%</td>
</tr>
</tbody>
</table>

Environment Agency State of the water environment indicator B3: supporting evidence
Evidence summary for policymakers:

Improving the UK’s freshwater quality

February 2022

Professor Sean Comber, University of Plymouth

Evidence summary for policymakers: Improving the UK’s freshwater quality

Other points for consideration

Introducing a systems approach to reduce pressures on freshwater ecosystems through integration with the delivery of other environmental objectives: the Government set out its environmental ambitions in the 25 Year Environment Plan (YEP). This considers what is potentially achievable for a given freshwater habitat site and argues that regulations need to include targets to achieve this. The YEP is supported by the Agricultural Transition Plan (ATP) which sets out the changes to agricultural policy in England from 1 January 2021. It replaces the current subsidy payment system for farmers and will move to a ‘systems’ approach that addresses the multiple pressures faced by ecosystems through the delivery of the Environmental Land Management scheme (ELM). This foresees farmers being paid to deliver “public goods,” such as “clean and plentiful water,” through ELM scheme agreements.

Both Defra and the Environment Agency (EA) have announced systems approaches to manage interactions between human and environmental systems. A systems approach requires consideration of the range of ecosystems across a catchment, their processes and the benefits they provide, as well as mitigating the multiple pressures facing them. With long-term funding and regulatory support, catchment-based approaches can help deliver sustainable water management in accordance with the YEP.

An effective monitoring programme of both farms and the wider environment provides a baseline for measuring compliance against environmental regulations. Monitoring data validates modelling outputs and indicates when inspections are required, leading to enforcement if necessary. The Environment Agency’s water quality budget is insufficient to monitor and assess progress against delivery of the Government’s objectives (which would require that all natural assets across the wider catchment area are included in monitoring). The budget is also too low for effective enforcement. The Environment Agency needs to receive appropriate funding to carry out this monitoring.

Tackling the disconnect in existing UK water policy: the Dasgupta Review on The Economics of Biodiversity recommended the development of a more integrated water management system in the UK using a polycentric style of governance. Working with stakeholders across every catchment in England should improve dialogue between stakeholders and develop more inclusive decision-making frameworks. It could also include establishing support networks for farmers as well as citizen science opportunities to engage local communities.

Farmers are encouraged to improve water run-off from land by undertaking new management measures to address water quality problems. Evidence shows that poor understanding of existing regulation leads to low compliance with freshwater policy interventions. The current values and culture in farming have been driven by a recent policy focus to increase production and reduce costs. Proactive funding and sustained engagement with farmers is required, supplemented by policy support to shift behaviours to address pressures. Successful mitigation will require clear targets and regulatory focus, co-ordinated payments to farmers and a joined-up approach with collaboration between all stakeholders and peer-to-peer learning.

A circular approach that matches supply with demand would reduce the need for imports and minimise phosphorus losses to the environment. Phosphorus sources from human sewage could be minimised and more effectively recycled, thereby reducing the demand for mineral fertiliser imports. Livestock slurries and manures could be recycled and converted to provide phosphorus and nitrogen fertilisers. There are currently regulatory and safety barriers to doing this which would increase costs for farmers although parts of the UK have a nutrient surplus (such as the Wye Valley), while others are in nutrient demand (such as East Anglia). The Environmental Audit Committee has recommended the UK Government undertakes research into the feasibility of livestock manure as a biofertilizer to be transported to arable farms to reduce dependency upon artificial fertilisers. This would reduce phosphorus from the high supply areas and reduce the amounts entering freshwater ecosystems.

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Supporting Literature


Professor Sean Comber is a Professor in Environmental Chemistry and Associate Head of School (Knowledge Exchange). He joined the University of Plymouth in 2012 following a career in consultancy. He has published more than 100 papers in peer-reviewed scientific journals and is the academic lead on a number of major projects within the water industry.

The Sustainable Earth Institute (SEI) connects the University’s world leading research expertise with the wider world to collaborate on creating a more sustainable future. We bring together researchers from natural and social sciences, engineering, arts, humanities, health and business, to take an interdisciplinary, systems-thinking approach to help tackle sustainability challenges.

This Policy Brief is part of a series aiming to inform policy-makers of our sustainability research, in particular around Net-Zero Carbon and Healthy Landscapes.

To read more in the series visit: www.plymouth.ac.uk/sei-impact

The University of Plymouth has a national and international track record in specific areas of data acquisition as well as the interpretation and visualisation of environmental data. It is currently working to draw these strengths together to deliver the next generation of environmental monitoring and assessment.

Building on research bases within environmental monitoring and fate, sensors, agri-tech, and biology we have formed a University-wide Sensors group, which is already forging new collaborations and gaining funding.

A three-time winner of the Queen’s Anniversary Prize for Higher and Further Education, the University of Plymouth is renowned for high quality, internationally-leading education, research and innovation.

Voice of a sustainable earth

Researcher biography

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