SUMMARY OF FINDINGS

STRIVE Report No. 91

Water Quality and the Aquatic Environment

Author: David Taylor, Yvonne McElarney, Sheila Greene, Chris Barry, Bob Foy, Phil Jordan
Lead Organisation: Trinity College, Dublin & Agri-Food and Biosciences Institute, Belfast

Anthropogenic eutrophication of rivers and lakes has become a major and persistent problem throughout the Irish Ecoregion. This project investigated the environmental influences over eutrophication drivers and effects in the Irish Ecoregion, and examined the success of several measures aimed at reducing eutrophication impacts. The mixed success overall of the measures studied highlight the need for improved understanding of the processes influencing the production and transport of nutrients and their impacts on aquatic ecosystems.

Key Words: Water Framework Directive, Nitrates Directive, Phosphorus regulations, Point and diffuse pollutant sources, agriculture, septic tanks.

Background

Anthropogenic eutrophication of rivers and lakes has become a major and persistent problem throughout the Irish Ecoregion. In response, measures aimed at reversing eutrophication and its effects have been implemented. These measures largely target the mitigation of inputs of phosphorus (P) and other nutrients. However, few studies have been carried out into the suitability and effectiveness of these measures and the factors that potentially influence recovery of rivers and lakes following their implementation. Focusing on the Irish Ecoregion, the EFFECT project aimed both to better understand the role of environmental conditions in mediating the effectiveness of measures aimed at reducing P and other nutrient inputs, and to determine the effects on surface water quality (rivers, streams and lakes) of their implementation in different geographic settings.

Key points

- Deterioration in water quality throughout Europe as a result of anthropogenic activity has led to the development and implementation of legislation at national and international levels and to the design and implementation of measures aimed at mitigating pollution impacts in freshwater bodies, including the impacts of increased loadings of nutrients, and in particular phosphorus.

- Although point sources of nutrients are important, diffuse sources from agriculture have frequently been identified as the main cause of nutrient enrichment in freshwaters and continue to prove a significant challenge to water-quality improvement efforts in the Irish Ecoregion.

- To date, reviews of the effectiveness of measures aimed at mitigating pollution impacts on freshwaters have tended to focus on levels of implementation and compliance; relatively little attention has been paid to water quality changes following implementation, or to improved understanding of the factors upon which successful implementation may be contingent.

- The EFFECT project sought to address this knowledge gap by evaluating changes in chemical water quality and biological water quality of a sample of freshwater bodies from across the Irish Ecoregion following implementation of a range of measures aimed at reducing inputs of phosphorus and other nutrients to water bodies, and by investigating why measures, once implemented, appear to be more effective in some locations compared with others.

Findings/Recommendations

- Phosphorus concentrations in freshwater bodies from across the Irish Ecoregion were found to be strongly influenced by environmental variables, notably slope, degree of soil saturation, run off risk, human population density and extent of pasture. The level of influence also varied according to season. These factors are also likely to determine the effectiveness of measures aimed at mitigating the effects of nutrient pollution from diffuse and point sources. Other factors that are likely to play a role in determining the effectiveness of implementation include the scale of the measure relative to the magnitude of the problem, the presence of invasives, the degree of habitat modification (e.g. hydromorphological modification of river channels), one off pollution events, and the time since a measure was introduced.

- The contribution of septic tanks to high phosphorus concentrations in rivers, particularly as constant point sources during low flows in the summer months, was a recurring theme in the EFFECT project and has relevance to many of the basic measures implemented under the WFD to enact national legislation for domestic septic discharges. Furthermore, phosphorus discharges from septic tanks may also confound the effectiveness of agriculturally focused programmes of measures, such as those prescribed under the Nitrates Directive.

- Improvements in low-flow water quality due to the replacement of a sample of defective septic tank systems yielded mixed results, most likely due to inter-subcatchment differences in the siting and functioning of septic tank systems and drainage and concurrent increases in septic system density from new-builds. Land use change in the study subcatchments may also have impacted effectiveness of improvements to septic tank systems and other relevant measures introduced during the time period of the study.

- Farm-based measures aimed at reducing nutrient loads to rivers have shown divergent outcomes. Farm pollution has been reduced and metrics of chemical water quality have improved. Improvements in biological water quality, based on macroinvertebrate composition, have not as yet followed reduced nutrient concentrations however.

- While low-order streams draining small catchments do not require monitoring under the WFD requirements, first-order headwater streams can contribute large proportions of water volume and nitrogen to higher-order streams. Moreover, a high proportion of stream length in a catchment is made up of streams < 10 m width. Low-order streams – and activities such as commercial forestry that are frequently associated with headwater catchments in the Irish Ecoregion – can thus have a major influence on water quality further downstream.

- The EPA has proposed to estimate lake-by-lake P loading standards through Vollenweider-type modelling of the response of lakes to P inputs. However, data from this study highlight that there are difficulties in using these models for lakes where the phosphorus cycle is not fully understood or has recently been altered – for example, by the activities of invasive species.

- Findings that both point and diffuse sources of phosphorus hindered the effectiveness of measures at different stages during the hydrological cycle provide a powerful argument for long-term monitoring that fully samples the flow range of rivers, especially in subcatchments with multiple potential sources of nutrients and sensitive environmental conditions (e.g. impermeable soils/high

densities of septic tanks). The Load Apportionment Model constructed by EFFECT researchers can potentially help here.

- Monitoring by the EPA in the Republic of Ireland currently targets a sample of sites that are regarded as representative, leaving many rivers and lakes unmonitored. However, under the WFD, regulatory organisations such as the EPA are obliged in 2015 to submit an up-to-date report of the chemical and ecological status of both monitored and unmonitored water bodies.

- Many programmes of measures have only relatively recently been implemented, and in some cases implementation is likely to have been partial at best. Given that water bodies in the Irish Ecoregion have been profoundly impacted by poor chemical water quality over several decades, expecting improvements in biological water quality and ecological functioning in rivers and lakes so soon after implementation of programmes of measures is perhaps overly optimistic.

- Some improvements to measures are recommended as a result of investigations carried out through the EFFECT project. Relatively narrow strips of riparian vegetation are clearly ineffective buffers against much larger-scale changes in catchment conditions. Moreover, some rivers and lakes have been profoundly modified hydromorphologically and through the activities of invasive taxa, and in these cases biological recovery is bound to lag behind changes in chemical water quality. Hysteresis can also be expected in some cases. As a consequence of these factors, the pathway of biological recovery of a heavily modified river or lake could potentially be very different from the expected.

- Future research should aim to place greater emphasis on relatively well-drained soils than was possible in the EFFECT project, and focus on understanding the links between sources, pathways, sinks and biological impacts of phosphorus and other nutrients, and the factors that potentially can modify pollution effects. Results of monitoring now being conducted for the WFD may be able to make a useful contribution here in refining and improving the models developed through the EFFECT project. Moreover, attention should be paid to the degree that programmes of measures have been and are being implemented.

For Further Information

Contact David Taylor (david.taylor@nus.edu.sg).

This report is published as part of the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme 2007–2013. The synthesis report is

published by the EPA and is available from
http://www.epa.ie/downloads/pubs/research/water/