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Agricultural Catchments Programme – nutrient delivery and impacts

Key external stakeholders:

Farmers, policy makers including Department of Agriculture, Food and the Marine, Department of the Environment and Local Government, Environmental Protection Agency and Teagasc research and advisory colleagues.

Practical implications for stakeholders:

The Good Agricultural Practice (GAP) measures introduced under the Nitrates Directive aim to reduce the risk to water quality from agriculture. Results from this research have implications for stakeholders in planning to achieve this objective.

- The impact of nutrient contributions from point sources needs to be considered when tackling impacted surface waters especially in less well-drained catchments.
- Evidence that current farm practices (influenced by regulation and schemes) are contributing to recovery in lake water quality, against a background of increasing farming intensity, suggests that further evaluation of the impact of the GAP measures on water quality is required.

Main results:

- Annual stream exports of P (0.12 kg/ha to 0.83 kg/ha) were low to moderate despite high rainfall and stream nitrate concentrations were below the maximum acceptable drinking water concentration of 11.3 mg/L in two representative arable catchments, monitored over two years using high resolution techniques.
- The phosphorus (P) Environmental Quality Standard (EQS) was impacted by a chronic signal of poor water quality during low flows (summer) which was likely to have a significant non-agricultural contribution.
- Meeting water quality targets is likely to be more challenging in the catchments with lower soil permeability due to lower summer dilution of point sources and higher diffuse nutrient losses during storms.
- Disproportionately high nitrate exports during winter confirmed that the closed period is synchronous with the period during which risks of incidental nutrient losses to water are highest.
- Sedimentary evidence from a drumlin lake suggests that since the late 1990s there has been a decrease in P enrichment of the lake water despite a local increase in agricultural intensification during this time.
- This decoupling of (increasing) external P source and (decreasing) P impact is proposed to be due to an increase in agri-environmental measures in this catchment and surrounding area.

Opportunity / Benefit:

Eliminating point sources offers an opportunity to reduce ecological impacts in streams and rivers from nutrient enrichment (particularly P). The evidence of a decrease in P enrichment of a lake despite a local to regional increase in agricultural intensification in recent years supports the comprehensive implementation of the GAP measures as an effective means to mitigating the impact of agriculture on water quality.

Collaborating Institutions: None

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1. Project background:

The first four-year phase of the Agricultural Catchments Programme (ACP) was completed at the end of 2011. This phase was concerned with the establishment of an extensive catchment scale experiment, and providing an agri-environmental baseline of agricultural activity and water quality response in the years following the implementation of the Nitrates Action Programme (NAP).

The NAP is concerned with mitigating the risk of loss of nitrogen and P to groundwater and surface waters and additionally the suite of measures in the NAP are recognised as the agricultural contribution towards helping to implement the Water Framework Directive objectives in Ireland. The hypothesis tested in the ACP is that the NAP is addressing these issues satisfactorily. The first phase of the ACP has provided significant evidence to support this hypothesis; assertions which will require validating in Phase 2.

The ACP integrates the bio-physical with the socio-economic processes in the evaluation of the impacts of the NAP measures. Conducted at the catchment scale, the evaluation was more concerned with the water quality response of the package of NAP measures in agricultural catchments, rather than individual measures. However, the status of some of the individual measures, as obligated under the NAP, was investigated. Six catchments were instrumented to monitor nutrient sources and loss pathways to surface and groundwater bodies. Intensive biophysical monitoring was conducted according to a common experimental design, with the aim of evaluating the effect of changes in farm management practices on the transfer of nutrients from source to water and their impact on water quality. Measurements, modelling and socio-economic studies were used to evaluate the efficacy of the measures and aspects of their cost effectiveness and economic impact.

2. Questions addressed by the project:

- Does catchment soil type influence P attenuation and loss?
- How much P is exported annually from the two arable catchments in the ACP?
- How are nutrient losses distributed over the year in these two catchments?
- How have P levels changed in a drumlin lake over the past century and a half?
- What evidence is there of the impact of changes in farm practices on P enrichment of the lake?

3. The experimental studies:

Export rates of nutrients and sediment are not regulated to standard thresholds but are considered to be important determinants of downstream water quality. Efficacy of the NAP measures at the catchment scale

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were evaluated by comparing end of catchment stream chemistry with water quality targets, and included measurements of phosphorus, nitrogen and suspended sediment in two hydrologically contrasting and intensively cropped catchments.

Ecological surveys have been conducted in all the ACP catchment streams in spring (May) and late summer (September) since September 2009 and will continue during Phase II of the ACP. These data are used to identify the link between land management and biological water quality and to identify water quality status according to WFD inter-calibrated chemical, hydromorphological and biological indicators. Macro-invertebrate analysis was conducted seasonally in all catchments except the karst limestone catchment in Mayo where sites downstream of the spring emergence were not suitable. Benthic diatom (siliceous unicellular algae) analysis was conducted seasonally in all six catchments. River hydromorphology was measured at each site once and a fish survey was conducted in summer 2010. Associated water chemical analysis was conducted on a monthly basis during low flow at each site.

Sreenty Lough is a small (0.17km2) lake in the Sreenty-Corduff paired catchments, Co. Monaghan. The lake catchment is 2.5km2. Despite being smaller than the 50ha WFD requirement for monitored lakes, it is representative of typical inter-drumlin lakes that are a characteristic feature of a large area of North-Central Ireland. Many of these lakes have shown susceptibility to eutrophication via P transfers from impermeable soils over several decades and especially post 1950. Two short 50cm sediment cores were extracted from the central deep basins of the lake and dated using standard techniques (Pb210 and Cs137). Core slices (1cm) were analysed in the laboratory for diatom sub-fossil remains and these results were used in an Irish lakes diatom-inferred total phosphorus (DI-TP) model.

4. Main results:

For two representative arable catchments monitored over two years using high resolution techniques:

- Annual stream exports of P (0.12 kg/ha to 0.83 kg/ha) and suspended sediments (3 t/km2 to 15 t/km2) were low to moderate despite high rainfall.
- Stream nitrate concentrations were below the maximum acceptable drinking water concentration of 11.3 mg/L.
- Disproportionately high nitrate exports during winter confirmed that the closed period is synchronous with the period during which risks of incidental nutrient losses to water are highest.
- Phosphorus loads were higher and the chemical Environmental Quality Standard (EQS; 0.035 mg/L) was exceeded in the arable catchment with lower soil permeability despite lower annual rainfall.
- The P EQS was also impacted by a chronic signal of poor water quality during low flows which was likely to have a significant non-agricultural contribution.
- Meeting water quality targets is likely to be more challenging in the catchment with lower soil permeability due to lower summer dilution of point sources and higher diffuse nutrient losses during storms.

Monitoring of in-stream ecology in all the catchment streams showed that:

- The ‘potential’ WFD macro-invertebrate status ranged from Poor to High (Q-value 3 to 4-5) across sites, seasons (late spring and late summer) and years. At least good WFD status was achieved in at least one year and site in four of the five surveyed catchments.
- During the September samplings, when pressures on in-stream biology are greatest, the Small Stream (macro-invertebrate) Risk Score showed that 80-100% of the sites surveyed across 5 catchments were ‘potentially’ at risk of not reaching good water quality status by 2015.
- During spring samplings there was an overall improvement in macro-invertebrate health, despite these samplings following the winter periods of proportionately highest nutrient loss to streams, but 50-60% of sites remained ‘at risk’.
- A stream algal-growth indicator (the trophic diatom index) showed that the karst limestone catchment was the only catchment (on average) without trophic impact. Seasonal variation at some sites in some catchments was also observed.
- Juvenile brown trout were found in the three southern catchments and not in the two North-Eastern catchments where downstream physical and/or water quality barriers to trout migration were identified.
- The ‘potential’ WFD river hydromorphological status ranged from Bad to Good across sites.

An investigation into lake impact and recovery showed that:

- Sedimentary reconstructions of historical lake water quality in Sreenty Lough show trophic impacts

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by P to be broadly coincident with other similar sized lakes in the region from the 1950s to 1960s.
- Most recently, since the late 1990s and especially post-2007, sedimentary evidence suggests a decrease in aquatic enrichment despite a local to regional increase in agricultural intensification during this time
- The decreased impacts were noted despite this lake having a high potential for internal P loading through seasonal anoxia and also a small apparent increase in soil in-wash.
- This decoupling of (increasing) external P source and (decreasing) P impact is proposed to be due to an increase in agri-environmental measures in this catchment and wider locale.

5. Opportunity/Benefit:

The disproportionately large impact of point sources, many of which are non-agricultural, presents an opportunity to reduce pressure on stream ecology by reducing or eliminating these sources. In many cases this would pose a lesser challenge than reducing diffuse losses from agriculture especially in less permeable catchments where the hydrological risk is high and agricultural source pressure is low.

P enrichment of Sreenty Lough has declined since the late 1990s and especially post-2007, despite a local to regional increase in agricultural intensification. This supports the contention that the implementation of the GAP measures by farmers has been effective in mitigating nutrient loss from farmland to water. This supports the comprehensive implementation of the GAP measures as the principal means of mitigating the impact of agriculture on water quality.

6. Dissemination:

Main publications:

Melland, A.R., Mellander, P.-E., Murphy, P.N.C., Wall, D.P., Mechan, S., Shine, O., Shortle, G. and Jordan, P. (2012). Stream water quality in intensive cereal cropping catchments with regulated nutrient management. Environmental Science & Policy, 24; 58-70.

O'Dwyer, B., Crockford, L., Jordan, P., Hislop, L. and Taylor, D. (in press). A palaeolimnological investigation into nutrient impact and recovery in an agricultural catchment. Journal of Environmental Management, doi. 10.1016 / jenvman / 2013.01.034.

Shortle et al., 2013 Agricultural Catchments Programme Phase 1 Report.
Teagasc. May 2013. ISBN1-84170-594-2

Popular publications:

Jordan P., Melland A., Mellander P-E., Wall D., Murphy P., Buckley C., Mechan S. and Shine O. (2011). Nutrient loads from agri-catchments: environmental risk or economic write-off? TResearch, 4(6), 12-13

Melland, A.R. & Mellander, P-E. Everyone wins by reducing nutrient loss. Teagasc Today's Farm Vol 22 Number 1 Jan/Feb 2011

7. Compiled by: Ger Shortle, Prof. Phil Jordan and Dr. Alice Melland

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