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Agricultural Catchments Programme – nutrient sources

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:

To reduce the risk to water quality, the Good Agricultural Practice (GAP) measures introduced under the Nitrates Directive aim to reduce soil phosphorus (P) levels where they are excessive to the optimum for farming. Results from this research have implications for achieving this objective.

- Expectations for water quality improvement through mitigating diffuse P from farming must also factor in lag time between implementation of soil P mitigation regulations and the reduction in soil P levels, P decline model uncertainty, land management variability, and time for P to transfer to and within river networks.
- The wide variability in soil P levels found at farm and field scale indicates scope to correct imbalances with better nutrient management.
- A better farm scale nutrient management tool, accounting for the influence of soil type and landscape hydrology could be useful to improve the spatial distribution of nutrients on-farm.

Main results:

- In four ACP catchments (two grassland-dominated and two arable-dominated) at a field P deficit scenario of 7 kg per hectare per year it was predicted that an average of between 5 and 20 years would be required for all Index 4 soils to reach Index 3. At a deficit of 30 kg it was predicted to take between 2 and 10 years.
- In 5 ACP catchments, between 6% and 26 % of soils had excessive P status, showing the legacy of historic P surpluses.
- Significant differences in P attenuation and loss were found between the catchments, reflecting different soil types. Regulations do not currently reflect these differences.

Opportunity/Benefit:

Improved nutrient management and use on Irish farms has the potential to deliver a 'win/win' outcome of better economic returns on fertiliser costs and reduced risk to water quality from nutrient loss to water. There is an opportunity for further gains in improved nutrient management if soil type and landscape hydrology were considered.

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:

- How long can it be expected to take, after the implementation of the GAP, measures for soils with excessive P levels (Index 4) to reach the optimum level for farming (Index 3)?
- What level of variability was there in soil P across and within the catchments and within catchment farms?
- Does catchment soil type influence P attenuation and loss?
- Is there scope to achieve more balanced spatial distribution of nutrients on farms?

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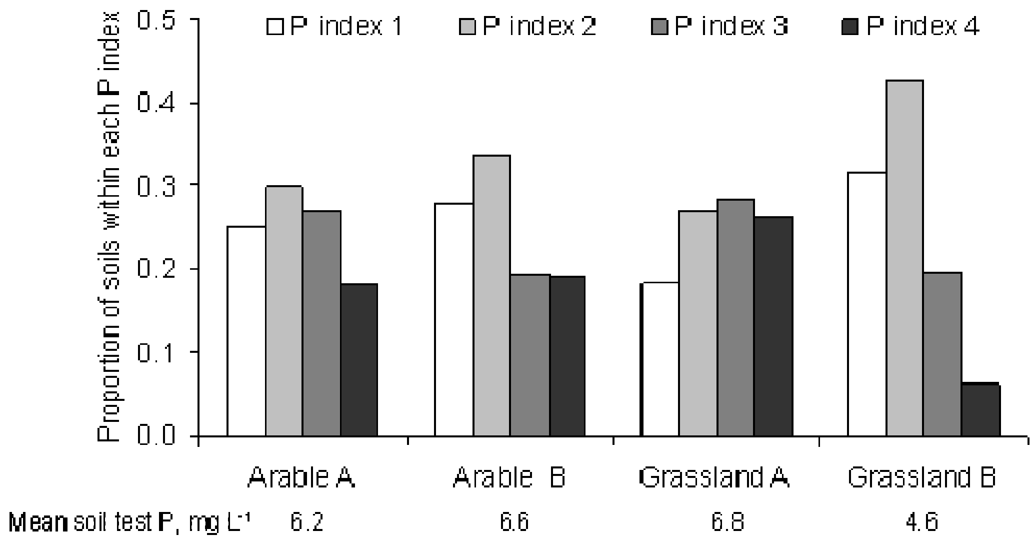
3. The experimental studies:

Two catchments representing a range of intensive grassland agriculture (beef and dairy production) with contrasting soil drainage characteristics (well-drained and poorly-drained) and two catchments with contrasting soil drainage characteristics representing intensive cereal production were selected to evaluate soil P changes in soils with high soil test P (STP) following the implementation of the GAP measures. Catchment fields were digitised and larger fields subdivided into soil sampling units of ca. 2 ha to account for differences in soil type, topography and management practices. The soils were analysed for Morgan's available P; national standard for plant available soil test P used in Ireland. The soils in each catchment were placed into the appropriate Index for grassland or arable production using the Irish Index system: Index 1 (very low), Index 2 (low), Indexes 3 (medium) and Index 4 (sufficient/excess). A model for predicting the trajectory of STP decline as a function of field P-balance, initial Morgan's P and initial total soil P was applied to the individual soil sampling units at P Index 4 in each catchment. Trajectories of soil P decline were assessed under three realistic field-scale P balance scenarios, under different limitations affecting P inputs (high, medium and low P deficit) and used to calculate the rate of P decline.

4. Main results:

Soil P status in the catchments reflects management history, with the intensive dairy farming catchment (Grassland A - Timoleague) having the highest number of soil sampling units in Index 4 and a higher mean P concentration of these Index 4 soils (19.74 mg l-1) than the less intensive grassland catchment (Grassland B - Ballycanew) (10.44 mg l-1). The two arable catchments had similar numbers of Index 4 soil sampling units and mean Index 4 P concentrations (14.27 and 15.68 mg l-1). Current soil P status reflects the legacy of historical management practices. High soil P status fields (Index 3 and 4) mostly occur in dryer fields or fields adjacent to farm yards.



Three field P deficit scenarios were modelled; at -30 kg P ha^{-1} there are no limitations to reduce STP (e.g. silage fields or arable fields with P applications withheld), at -15 kg ha^{-1} there are some limitations to reducing STP (e.g. silage fields or arable fields with only slurry P applications) and at -7 kg P ha^{-1} there are severe limitations to reducing STP (e.g. a grazed field on a farm with all fields in Index 4, a reasonably high stocking rate and with slurry recycled evenly across the farm). At a field P deficit scenario of -7 kg P ha^{-1} it was predicted that an average of between 5 and 20 years would be required for all Index 4 soils to reach Index 3 (< 8 mg l^{-1}). At -30 kg P ha^{-1} it was predicted to take between 2 and 10 years. For the intensive dairy catchment (Timoleague), the model predicted that there will still be soils in Index 4 in 2015 (WFD reporting year), even at a deficit of -30 kg P ha^{-1}, reflecting the higher number of soils with very high STP values in this catchment.

A number of points were highlighted regarding the current NAP measures and their effects. On non-derogation farms, if no soil test is available, fertiliser P can only be applied at a replacement rate which limits the P inputs and potential build up. However, where soils have sub-optimal STP levels (Index 1 and 2) the restriction of P application may have a negative impact on yield and quality of crops. Nevertheless, P additions at replacement rates on soils already above optimum (Index 4) may present a further P transfer

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risk. While the less intensive grassland catchment has a lower proportion of Index 4 fields and these are predicted, on average, to decline rapidly, other evidence (see Jordan et al., 2012) suggests that this Grassland B catchment is more risky due to soil hydrological properties rather than soil chemical properties. The current NAP measures do not explicitly account for these other factors affecting P loss risk.

The decline to optimum soil P status remains a desirable aim for both agronomic efficiency and environmental risk objectives. Expectation of soil P decline can be realised under P deficit scenarios but concerted effort on management and advice needs to be focussed to realise these deficits without losing production.

At the farm level, whole farm P balances for 5 sample farms (one in each catchment) in 2010 showed that the dairy farm in the lowest intensity grassland catchment had the highest farm gate surplus (16.5 kg ha-1), while the beef-tillage farm in the winter-wheat dominated arable catchment had the highest farm gate deficit (-12.6 kg ha-1). The tillage-lamb farm in the Spring barley-dominated arable catchment (1.7 kg ha-1), the dairy farm in the intensive dairy catchment (1.9 kg ha-1) and the beef-lamb farm in the grassland catchment of intermediate intensity (-0.7 kg ha-1) were closer to being in balance. However, when the soil P requirement is considered (level of fertiliser P required to build-up and maintain agronomic soil P levels), these balances become negative, even for the highest dairy farm surplus above. An intensive dairy farm with an N derogation in the intensive dairy catchment had just 4% of the farm area requiring soil P additions and low P fertiliser imports on this farm resulted in an overall farm P deficit of -4.5 kg P ha-1.

At the field scale, large spatial variability was found, indicating scope to correct imbalances with better nutrient management on farms and redistribute P to lower status soils, potentially increasing P use efficiency and decreasing P loss risk. Trends in soil P status, fertiliser P inputs and surplus P availability can be misrepresented at larger scales (national, catchment, farm scale) and may be better represented at smaller scales (field, soil process scale) where management and soil factors can be considered.

5. Opportunity/Benefit:

The outcomes of this project can be used by policy makers and regulators to reassess their expectations for water quality improvement through diffuse P source mitigation and they can now factor in additional time for P decline model uncertainty, land management variability and time for P to transfer to and within river networks.

The results also indicate that a better farm scale nutrient management tool, accounting for the influence of soil type and landscape hydrology could be useful to improve the spatial distribution of nutrients on-farm.

6. Dissemination:

Main publications:

Jordan, P., Melland, A.R., Mellander, P.-E., Shortle, G. and Wall, D. (2012). The seasonality of phosphorus transfers from land to water: Implications for trophic impacts and policy evaluation. *Science of the Total Environment*, 434, 101-109.

Wall, D.P., Jordan, P., Melland, A.R., Mellander, P-E., Mechan, S., and Shortle, G. 2012a. Forecasting the decline of excess soil phosphorus in agricultural catchments. *Soil Use and Management*. Doi: 10.1111/j.1475-2743.2012.00413.x.

Wall, D.P., Murphy, P.N.C., Melland, A.R., Mechan, S., Shine, O., Buckley, C., Mellander, P-E., Shortle, G. and Jordan, P. 2012b. Evaluating agricultural nutrient source regulations at different scales in five Irish catchments. Environmental Science and Policy 24, 34-43. Doi:10.1016/j.envsci.2012.06.007.

Popular publications:

Treacy, M., Nutrient Management is a sweet success, *Today's Farm*, Vol. 22 No.3, p.34-35 May-June 2011.

Wall, D.P., & Shortle, G,. 2011. Securing Irelands N derogation: the Agricultural Catchments Programme. *TResearch*, Vol. 6: Number 1. Spring 2011.

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