Phosphorus management for improved water quality

A TEAGASC study dug deep into the factors affecting phosphorus levels on two catchments in Louth and Wexford.

Irish soil fertility levels have remained well below optimum requirements for productive agriculture, with 60 % of soils deficient in phosphorus (P). This is limiting the ability of many Irish farms to contribute to national expansion targets set out under Food Wise 2025. P is a primary soil nutrient and plays a vital role in stimulating early plant development. However, it is also a key limiting nutrient for algal growth in rivers and lakes; therefore, when elevated P concentrations enter freshwater systems, the water quality declines. This is impacting on Ireland's goal to improve water quality and achieve its EU Water Framework Directive targets.

Under the EU Nitrates Directive, the Good Agricultural Practice (GAP) regulation measures (SI 605 of 2017) are implemented to reduce the risk of P losses to water bodies from agriculture. Since 2009, the Agricultural Catchments Programme (ACP) has been monitoring and evaluating the impact of these GAP measures on achieving good water quality, while sustaining or increasing farm viability across a range of soil types, farm enterprises and intensities.

Farm vs field scale

Nutrient management planning (NMP) is a GAP measure designed to reduce high levels of soil P. It is typically conducted at the whole-farm scale, in which maximum farm P fertiliser application limits are set according to the farms' crop types, stocking rate and soil test P (STP) levels. This farm-scale approach to manage STP levels by either building up deficient soils (Index 1 and 2) or drawing down high STP soils (Index 4) towards optimum (Index 3) is related to the P balances operating at the farm scale. A P balance is the difference between P inputs (i.e., manures and animal feed) and P outputs (i.e., meat, milk and arable crops) in the farm system. However, hotspots of agronomic underperformance and/or environmental risk that are occurring within the farm may not be clearly identifiable.

A catchments study

To identify such hidden trends and account for P distribution, the ACP recently published a study (McDonald *et al.*, 2019) that carried out a detailed audit of field-scale balances and assessed STP trends within two (<11.5 km^2) catchments (Castledockrell, Co. Wexford and Dunleer, Co. Louth) of mixed land use over a four-year period (2010-2013). Farm management data supplied from the ACP farmers was utilised to calculate field P inputs off-takes, and P balances, using a similar balance calculation to that described for determining farm gate balances. In this study the same catchment fields were sampled and analysed for STP at the start of the study period (2009/2010) and this was repeated four years later (2013/2014). This facilitated the calculation of soil P balances, i.e., field P balance minus the P build-up requirement of the initial STP.

Field P: trends and variability

Driven by increased chemical fertiliser P inputs, the field balances in the Castledockrell catchment had an average surplus P ranging from 1.9 kg/ha per year in 2011 to 7.5 kg/ha per year in 2013. However, between the study period 2010 to 2013, the average STP levels declined as the area deficient in STP increased from 60 % to 67 %, with the area of excessive soil P concentrations (Index 4) decreasing

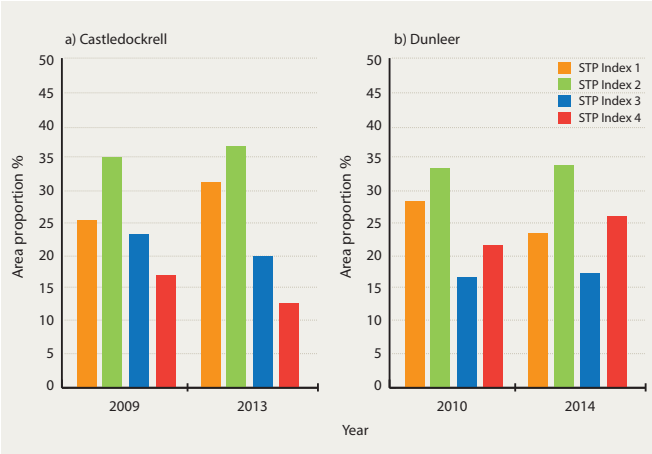

FIGURE 1: Percentage area of soils within each STP index (1-4) in the (a) Castledockrell and (b) Dunleer catchments between 2009 and 2013/2014.

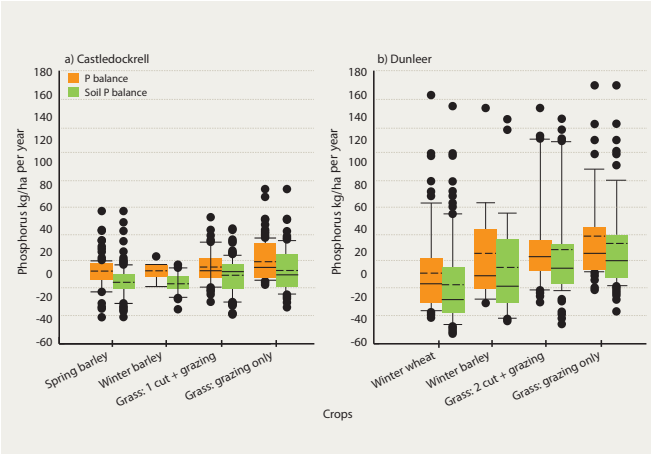

FIGURE 2: Distribution of field and soil P balances of the four main crop types across the (a) Castledockrell and (b) Dunleer catchments. Dotted line represents the average.

by 8 % (**Figure 1**). Similarly, in Dunleer the average annual fertiliser P inputs increased the surplus field P from -0.42 kg/ha per year in 2010 to 25.5 kg/ha per year in 2013, but the area of excessive soil P concentrations increased by 4 % (**Figure 1**). In part, this increase is attributed to some fields receiving excess applications of organic manures above crop requirements. Examination of the average field and soil P balances across the main crop types in both these catchments found that there was a large variability of P management across and within crop type (**Figure 2**). While there was an indication of a response to GAP measures in Castledockrell, for both catchments it is evident that the distribution of P sources within farms was poor, as P inputs often did not match crop and soil P requirements at the field scale.

Future implications and recommendations

Farm gate balances are important indicators for recognising changes in nutrients at the farm scale. However, this study demonstrates the need to account for P balance at the field and even sub-field scale to help identify where P can be retained or lost from the agricultural landscape. This study highlights the need for improved supports to enhance knowledge transfer mechanisms that can deliver better farm and soil-specific NMP strategies for farmers. Emphasis is also needed on better distribution of organic manures within farms, especially in catchments that neighbour confined units such as pig, poultry and mushroom enterprises. Without these considerations, achieving the dual benefits of improvement to water quality targets and increased crop output from the landscape may become restricted.

References

McDonald, N.T., Wall, D.P., Mellander, P.E., Buckley, C., Shore, G., Leach, S., *et al.* (2019). 'Field scale phosphorus balances and legacy soil pressures in mixed-land use catchments'. *Agriculture, Ecosystems and Environment*, 274: 14-23.

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