A new approach for monitoring the fate of agricultural herbicides

Weed management is an essential part of good agricultural management and yet the fate of herbicides following application, beyond weed control, is not fully understood. TEAGASC research developed a multi-dimensional monitoring approach to address this knowledge gap and applied it in two Irish river catchments.

This research was part of the EU Horizon 2020-funded WaterProtect project, with partners in seven member states and undertaken in two of the Teagasc Agricultural Catchments Programme sites in Co. Wexford – Ballycanew and Castledockrell.

Following application, and beyond their action on weed plants, herbicides are designed to degrade in soils. However, before this can fully occur, herbicides and metabolites associated with partial degradation can be lost from soil surfaces during rainfall. This can be in water that moves across the land surface (as runoff) to rivers, or into groundwater (by leaching). If this river or groundwater is subsequently used as a drinking water source, it may present a health issue if concentrations exceed a limit as regulated by the EU Drinking Water Directive. These limits are 100 ng/L for a single pesticide or 500 ng/L for the sum of all pesticides (i.e., herbicides, insecticides, fungicides). Herbicide degradation, runoff and leaching is influenced by the physical and chemical characteristics of soil, subsoil, bedrock, land use, management practices, timing of pesticide application and prevailing environmental conditions.

This means that monitoring for herbicides only a few times per year in rivers or groundwater (as is normally done in Ireland) may not provide useful enough data to assess environmental or human health risks.

WaterProtect

The WaterProtect research developed a new monitoring approach that addressed all of these factors by monitoring multiple herbicides in rivers using passive samplers that captured all flow conditions over a one-year period, and in 95 groundwater wells. This was undertaken in grassland and arable land use settings in the two Wexford catchments and so, overall, can be considered a multidimensional approach.

Of the 18 herbicides screened by the passive samplers, MCPA, fluroxypyr, mecoprop, 2,4-D and triclopyr were detected in variable concentrations throughout the monitoring period in the two catchment rivers. Time-weighted average concentrations of individual herbicides ranged from below the limit of quantification (LQ) to 262.9 ng/L in the Ballycanew catchment and from below the LQ to 127 ng/L in the Castledockrell catchment (**Figure 1**).

The total herbicide concentrations ranged from 8.9 to 472.6 ng/L in Ballycanew and 0.9 to 169.1 ng/L in Castledockrell. In both catchments herbicides were present in the streams throughout the year, and there were large seasonal and temporal variations in their types and concentrations (**Figure 1**). In winter, losses of herbicides were likely to be from legacy soil stores that were mobilised during high rainfall conditions, indicating imperfect degradation. Herbicide concentrations were low during this period, but mass loads were high (concentration multiplied by river discharge). Occasionally, concentrations of MCPA, triclopyr, fluroxypyr, clopyralid and mecoprop were in excess of the EU regulatory limit, mainly in the Ballycanew catchment. High concentrations of herbicides in summer were associated with incidental losses (rainfall following application) and lack of dilution during low flow. This highlights the importance of physical conditions in the catchments where contrasting controls on flow paths were instrumental in controlling such losses to rivers. Herbicides were also detected in 38 % of samples of groundwater wells across the catchments (**Figure 2**). The concentrations of all herbicides in different areas were highly variable and comparatively low concentrations were detected in Castledockrell. In Ballycanew there were high detections of clopyralid (619 ng/L) and triclopyr (650 ng/L), highlighting a large variability in these herbicides and sometimes exceeding the regulatory limit.

Implications for practice

These results fill gaps in our understanding of herbicide transfer to water that are important for developing collaborative mitigation

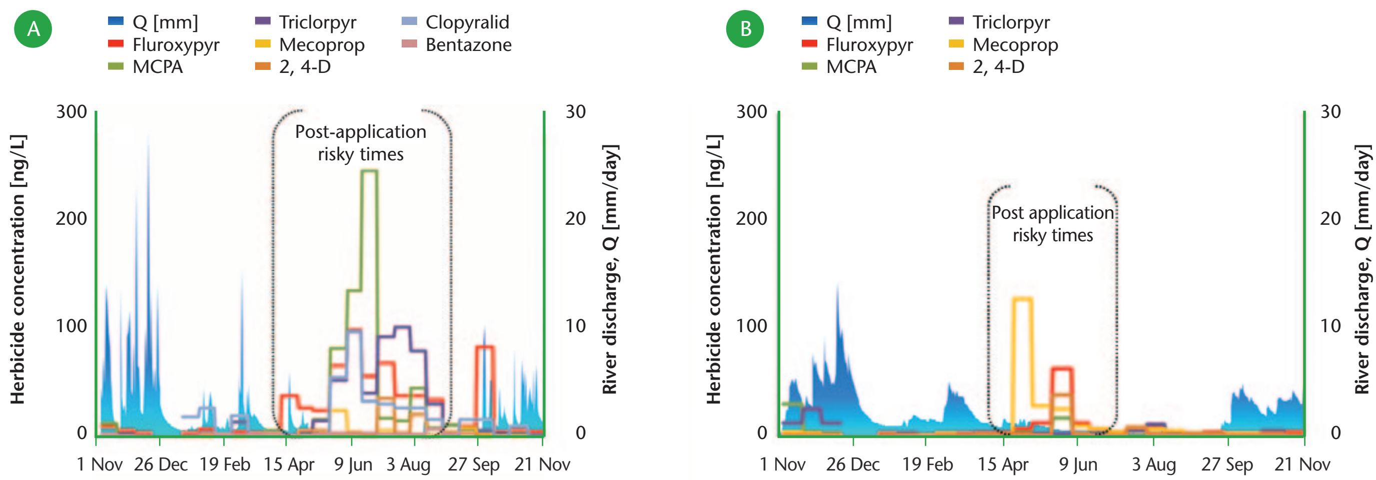

FIGURE 1: Herbicide concentrations (ng/L) in river and river flow (mm/day) in: a) Ballycanew catchment; and, b) Castledockrell catchment during the monitored period November 2018 to November 2019.

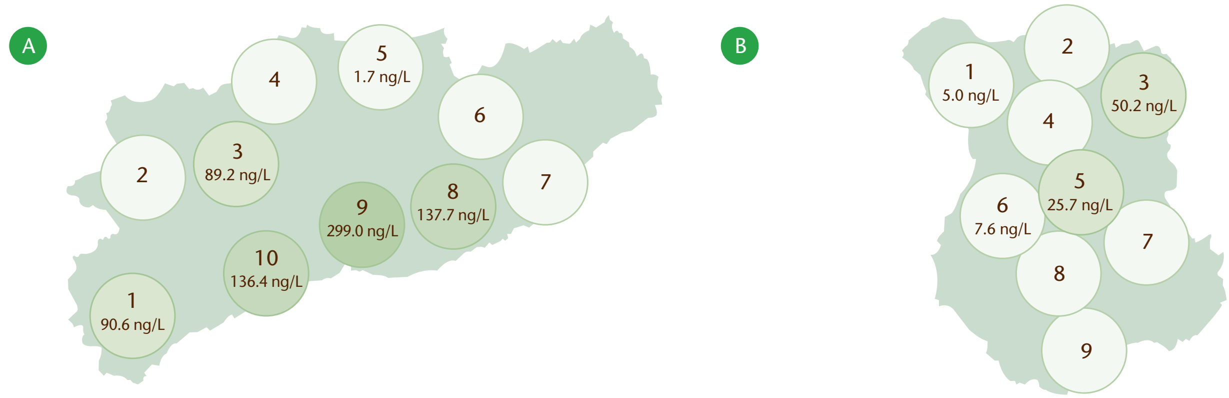

FIGURE 2: Herbicide concentrations (ng/L) in drinking water wells in: a) Ballycanew catchment; and, b) Castledockrell catchment. Values in individual circles represent average sums of detected herbicides in different areas across the two catchments.

strategies. Such strategies need to consider risky areas and risky times for the application of herbicides (and all pesticides) to avoid both incidental losses and build-up in soils. Such areas and times vary with different physical settings and land use, and efficient measures could be associated with changes in the handling and application of herbicides. This multidimensional and whole catchment approach provides the most detailed assessment of herbicide fate on agricultural land. The method can be used wherever pesticides are an unintended pollution problem and the datasets can be used as important knowledge exchange resources.

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Authors

Majid Ali Khan
Research Technologist, Teagasc, Environment and Land Use Programme, Johnstown Castle, Co. Wexford
Corresdondence: makjadoon@hotmail.com

Fabiola Barros Costa
Research Technologist, Teagasc, Environment and Land Use Programme, Johnstown Castle, Co. Wexford

Per-Erik Mellander
Senior Research Officer, Teagasc, Agricultural Catchments Programme, Environment and Land Use Programme, Johnstown Castle, Co. Wexford

Phil Jordan
Professor of Catchment Science, School of Geography and Environmental Sciences, University of Ulster, Coleraine, UK