Pesticide risk indices: A review of practical implications for policy and interpretation

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Summary

Pesticide Risk Indicators

Pesticide risk indicators (PRI) provide measures of non-target impacts arising from the use of Plant Protection Products (PPP), specifically relating to effects on human and animal health and the environment. Here, the term 'risk' combines both the scale and the likelihood of the impact. A key challenge for policy makers and other stakeholders is the development of tools to adequately characterise these risks to support decision making, particularly around when and what to spray and the interpretation of trends in relative usage and overall impact.

Conditions under which PPPs are applied vary considerably, and the physical processes by which organisms might be exposed are hugely complex. This makes it extremely difficult to characterise the true impacts of PPPs in a cost effective and consistent manner. PRIs generally provide proxies based on standard application scenarios and more readily available information (e.g. on amounts of PPP products applied, results of laboratory testing or known chemical properties such as toxicity on model species or persistence in the soil/freshwater environment). PRIs are intended to provide simple, practical tools to characterise the potential impacts.

Types of pesticide risk indicators reviewed

Five categories of PRI are discussed, with examples highlighting those with the greatest relevance for policy decisions in the UK or EU Member States and particularly those used in National Action Plans to promote the sustainable use of PPPs. The specific classes of indices include:

'Quantity only' measures, which describe the amount of PPP applied based on various underlying measures, without reference to relative toxicity or other chemical data. Key examples include economic indicators of sales, the quantity of active substance applied (QA), the number of unit doses (NUD), the treatment frequency index (TFI) and the standardised treatment index (STI).

Qualitative indicators, which rely on expert opinion or simple chemical designation such as 'Risk phrases' or chemical class as used in the EUs harmonised risk indicators (HR1 and HR2). The fuzzy expert index I-Phy index is included here due to semi-qualitative 'grading' of expert opinion.

Weighted multi-component PRIs is a large class of PRIs, which use the toxicity or chemical properties of a substance within a mathematical formula to generate an overall active substance 'score', as the basis for risk assessment. Examples include the Environmental Impact Quotient (EIQ), the Norwegian Environmental Risk Indicator (NERI), the Danish Pesticide Load Indicator (PLI) and PestScreen.

Exposure toxicity ratio (ETR) methods explicitly include an estimation of the concentration ('exposure') of substance within a specified environmental 'compartment' (such as nearby freshwater) based on local conditions around application (e.g. recent rainfall). Risk in these measures is expressed based on the ratio of exposure to the toxicity, with toxicity based on testing of relevant laboratory organisms. Examples discussed include the Synoptic Evaluation Model for Plant Protection Agents (SYNOPS), the Environmental Yardstick for Pesticides (EYP), p-EMA, the Pesticide Occupational and Environmental Risk Indicator (POCER) and various 'harmonised' indicators developed through EU or OECD research efforts.

Mechanistic and complex models, also referred to as process-based or fate models, aim to simulate the physical processes involved in the transport or movement of PPPs through various environmental compartments, most notably soil, groundwater and runoff. Although not generally used as PRIs directly, these often underpin other approaches, particularly the exposure toxicity ratio family.

Summary of Key findings

- Many PRIs have been developed, for different purposes and with varying assumptions and underlying data. Different PRIs applied to the same dataset may lead to different results, so the choice of PRI can have a major consequence for the perception of risk. Prospective users therefore need to understand the scope and usefulness of different approaches to generating PRIs.

- Quantity only indicators make no distinction between different substances, effectively treating risk associated with all PPPs as being equal by mass. This is clearly inadequate for describing how pesticide impacts can be lowered by switching to alternative substances. This crudeness has been the catalyst for the development of the more complex PRIs.

- Some quantity only indicators, e.g. TFI and NUD, attempt to incorporate frequency and intensity of treatment into measures of the amount of PPP applied. However, there is little evidence that these perform consistently better than the basic QA measures of overall mass as approximations of more complex methodologies.

- Inevitably as you move from simplistic PRIs like QA, to more complex PRIs, there is greater demand for supporting data and computational resources. There is then understandable interest is seeing how well simplistic PRIs approximate the results of complex PRIs. However, at present there is limited evidence to suggest that 'quantity only' indicators can approximate the behaviour of more complex and more scientifically justified indicators.

- International efforts have been made to develop harmonized environmental indicators for pesticide risk. While such indicators would provide many benefits, there is limited evidence for their use in a practical policy context, likely because those countries placing the greatest emphasis on PRI development often have their own competing National PRIs. Harmonized approaches in the EU have also been held back because of the lack of harmonised data on PPP usage. This is hindered by current regulations, which only require data to be reported for a reference period of a maximum 12 months at any time within a five-year period, and data on agricultural PPP use have only been recorded since 2015.

- Despite the many PRIs that have been used and the extent to which they have been adopted, no examples could be found of studies where PRIs have been assessed in terms of impact on an ecologically relevant end point, e.g. the change in population of a vulnerable species. This is primarily a reflection of the difficulties of conducting such as assessment at realistic field scales.

- There are also some concerns about the challenges of including both human health and environmental impacts within a single PRI approach, as this can involve trade-offs. Different components/populations may be included with varying degrees of complexity.

- PRIs are used in practice as tools for decision making by farmers and advisors; tools for surveillance and monitoring; and tools to support policy and regulation. In all cases the most detailed PRIs are based on comprehensive systems recording pesticide usage, for example, perhaps the most significant example of PRI in surveillance - the Danish PLI.

- The most notable examples of PRIs used for policy are the various approaches used in different European countries that link pesticide taxation and specific PRIs. The success of these instruments in achieving impact reduction objectives has been mixed. Even with arguably the most successful scheme–the Danish PLI–substantial reductions in non-target impact have not resulted in corresponding reductions in the amount of PPP use (expressed using the TFI). This has been attributed to limitations in the underlying economic model to account for stakeholder incentives, particularly around perceptions of risk and motivations for behaviour.

- The French Ecophyto schemes, yet to show success in terms of PPP reduction targets, are notable for the Government investment in training and technical guidance provided to farmers, including the DEPHY network of 1,900 demonstration farms (planned to be expanded to 3,000), which has been highly successful in development and communication of approaches towards the reduction of PPP use while maintaining productivity.

- Data availability is key issue to developing meaningful PRIs. In terms of recording PPP use, the UK Pesticide Usage Survey (PUS) provides an intermediate level between the robust and near universal recording systems of Denmark and California, and the extremely aggregated and sparse sales records available for many other EU Member States. The current UK surveillance lacks sophisticated GIS and scenario-based tools, which could provide links to soil and elevation maps, and distances between fields and environmental features. It might not be possible to link this with the current UK surveillance regime, but it is worth considering in the context of farmer and advisor decision support tools.

- Pesticide risk indicators are a valuable tool, applicable at multiple operational levels, and with potential to inform a wide range of decisions around the use of PPPs. The key challenge however lies in moving beyond specific indicators for a specific decision, towards a more generalised and harmonized approach that helps different stakeholders be consistent in how they relate risk to non-target systems, as well as building trust in the developed methods.

- As modern farming becomes increasingly sophisticated and as the scope for automated and standardised big data continues to grow, many PRIs may find a new role in the next generation of decision support tools, national monitoring networks and/or any revisions to the authorisation process. But at present the lack of coherent and accessible data resources make this challenging.

- In developing and adopting future PRIs, there would be a need for carefully managed stakeholder engagement, transparency and clear communication, given the traditional scepticism of UK stakeholders around indicators in general, and the uncertainty associated with the PUS data.