Development of a UK higher tier groundwater environmental risk assessment for pesticides

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Introduction

At present there are limited options for higher tier refinement of exposure estimates of pesticides leaching to groundwater (GW) outlined within the UK regulatory process. This poster describes the development of a spatially distributed higher tier (HT) modelling approach (Tier 3b) drawing on the example of the UK Higher Tier Drainflow as well as the NL GeoPEARL approaches.

Methodology

The methodology drew upon existing CRD and FOCUS guidance where possible.

Soils - All soils series in England and Wales were classed into one of 15 soil classes using the NATMAP5000 product. These classes reflected:

1. 7 soil classes that are free draining and would contribute to groundwater;
2. 4 soil classes that contribute to groundwater at 1m depth, but would ordinarily have agricultural drains and largely impermeable lower boundaries;
3. 2 soil classes that are peaty and the leaching of PPPs to groundwater would not be expected owing to their high organic carbon contents;
4. 2 soil classes overlying substrates that are largely impermeable and the leaching of PPPs to groundwater would not be expected;

Landuse - The ADAS 2010 landuse database at 1 km resolution was used to identify the extent of winter wheat production on the defined soil classes in England and Wales.

Weather/Climate – Akin to the UK HT drainflow ERA, four stations were selected to represent <600 mm, 600 mm-750 mm, 750 mm-1000 mm and >1000 mm climates with respect to the production areas of cereals. The four stations selected were Rosewarne (>1000 mm), Hillsborough (750-1000 mm), Wisley (600-750 mm) and Cambridge (<600 mm). Thirty-six year records were compiled by replicating the first six years of the 30 year climate dataset for each station to allow for model spin up, using the full 30 year dataset for the model run. The resulting extent of crop on each soil class in each climate region is summarised in Table 1.

Modelling - The MACRO v4.4.2 and PEARL v4.4.4 models provided for standard FOCUS modelling were used to simulate the amount of active ingredient leaching to groundwater for drained and undrained soils, respectively. Presented is an example using a mobile, moderately persistent compound applied to winter wheat.

Results

The 80th percentile predicted environmental concentrations (µg/L) in water leaching below 1 m depth to ground water for all of the scenarios was extracted (See Figure 2a). The drained soils concentrations at 1 m are affected by negative water and pesticide fluxes owing to the influence of the drains at depths of 90 to 100 cm.

These scenario concentrations, when combined with the area that they represent (See Table 1) were used to define a cumulative frequency distribution (See Figure 2b). The 80th spatial percentile is ~0.24 µg/L.

The lighter (sandy) soils are most likely to be cropped in spring and as such the change in this application timing was explored (See Figure 3a). The resulting 80th spatial percentile is reduced to ~0.13 µg/L.

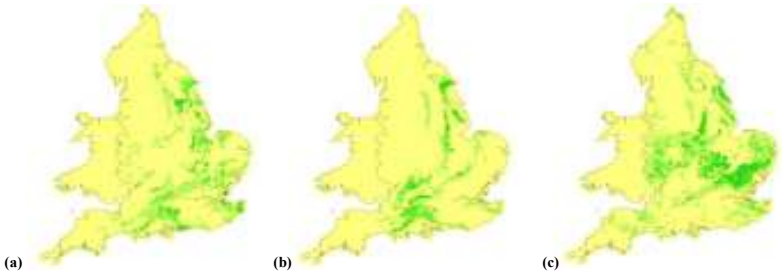
A label restriction to restrict application to soils with a sand content of <50% was also explored, albeit CRD are averse to such spatially varying label restrictions. This reduced the 80th spatial percentile to <0.01 µg/L.

Discussion

Results from standard FOCUS$_{GW}$ scenarios relevant to the UK range from 0.04 µg/L to 0.43 µg/L for autumn application and from 0.02 µg/L to 0.28 µg/L for spring applications (See Figure 3b). Comparison of these with the HT GW results suggests that this HT GW approach may not always reduce the GW risk significantly, however, it does provide a means by which to define risk mitigation and target post registration GW monitoring.

Further work

While this is a good initial exploration of this UK HT GW ERA, further exploration would enable a better understanding of how it performs for a broader range of compound types applied to a more diverse range of crops. Further refinements on the co-location of crops and light textured soils are possible using higher resolution (1 km soils) and more recent (2014 landuse) datasets.



(a) (b) (c)

Figure 1: Distribution of the soils classes under winter wheat production in 2010 illustrated for (a) East Keswick, (b) Newmarket and (c) Salwick.

Soil Class	Average Annual Rainfall Zone				
	<600 mm	600-750 mm	750-1000 mm	>1000 mm	Total
Blackwood	0.64	0.79	0.25	0.00	1.68
Parkgate	2.45	1.19	0.30	0.06	4.00
Quorndon	0.47	0.56	0.21	0.02	1.26
Wallasea	4.03	2.67	0.27	0.01	6.98
Aberford	0.97	4.55	2.14	0.26	7.92
East Keswick	3.06	3.95	2.51	0.13	9.66
Fyfield	1.36	1.61	0.55	0.06	3.59
Givendale	0.07	0.10	0.11	0.00	0.28
Newmarket	0.63	3.38	2.92	0.07	6.99
Newport	1.21	4.57	0.71	0.03	6.52
Salwick	6.26	9.74	1.81	0.25	18.06
Peat Lowland	1.12	0.45	0.14	0.00	1.71
Peat Upland	0.00	0.02	0.06	0.03	0.12
Slowly Permeable	3.61	11.72	1.63	0.23	17.20
Impermeable	4.01	7.24	2.14	0.63	14.03
Total	**29.91**	**52.53**	**15.76**	**1.80**	**100.00**

Table 1: Percentage of crop and soil extent within each climate scenario.

Acknowledgements

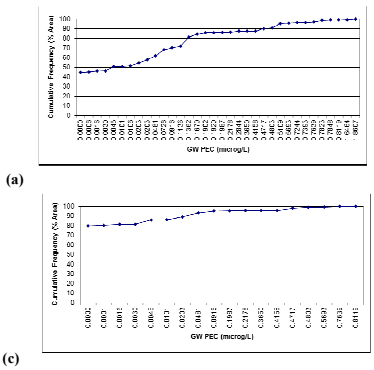
J. Hollis for assistance in defining the soils classes

Soil Class	Average Annual Rainfall Zone			
	<600 mm	600-750 mm	750-1000 mm	>1000 mm
Blackwood	0.76391	0.480343	0.569325	0.365001
Parkgate	0	0	0	0
Quorndon	5.69E-04	0	0	0
Wallasea	0	0	0	0
Aberford	0.001568	0.004478	0.091619	0.198742
East Keswick	0.020282	0.048067	0.471708	0.811944
Fyfield	0.186791	0.335969	1.055294	1.563768
Givendale	0.003000	0.010054	0.217807	0.415750
Newmarket	0.017974	0.034648	0.246858	0.427939
Newport	0.509207	0.860216	2.554341	3.485996
Salwick	0.127114	0.243917	1.116966	1.605454
Peat Lowland	0†	0†	0†	0†
Peat Upland	0†	0†	0†	0†
Slowly Permeable	0†	0†	0†	0†
Impermeable	0†	0†	0†	0†

† Assumed PEC based on the attributes of the soils and the permeability of the underlying parent material;

(a) (b)

Figure 2: Baseline results: (a) The 80th percentile predicted environmental concentration of soil water draining below the 1m target depth and (b) Cumulative frequency (area %) of the 80th percentile leaching concentration.



(a)

Scenario	Model	Predicted Environmental Concentration (µg/L)	
		Autumn Application	Spring Application
Châteaudun	MACRO	0.2420	0.0611
Châteaudun	PEARL	0.0402	0.0176
Hamburg	PEARL	0.2649	0.1836
Kremsmünster	PEARL	0.2054	0.1567
Okehampton	PEARL	0.4299	0.2738

(b)

(c)

Figure 3: (a) Cumulative frequency (area %) of the 80th percentile leaching concentration for the spring application mitigation; (b) Results from standard FOCUS$_{GW}$ scenarios relevant to the UK; Cumulative frequency (area %) of the 80th percentile leaching concentration for the sandy soils (<50% sand) mitigation