CAN VULNERABILITY MAPS EXPLAIN PESTICIDE FINDINGS IN GROUNDWATER?

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BACKGROUND

» Frequent detects of PPPs and metabolites in (shallow) groundwater

» Monitoring program by Flanders Environment Agency: shallow groundwater, +/- 180 wells each year
We developed a tool to calculate groundwater vulnerability maps for PPPs

- Substance-specific
- As much as possible process-based (incl. saturated zone)
- Making optimal use of existing Flemish/Belgian datasets and models
- At different scales (Flanders and local)

We consider in this study ‘specific vulnerability’ taking into account subsoil characteristics and substance characteristics
REGIONAL SCALE VULNERABILITY

Leaching to groundwater - GeoPEARL

» Hydrological model SWAP
» Pesticide fate model PEARL

**SWAP hydrology**
- precipitation
- irrigation
- transpiration
- crop calendar
- soil evaporation
- throughfall
- ponding
- heat flow
- water uptake by plant roots
- fluctuating groundwater level
- seepage
- lateral discharge to ditches and field-drains

**PEARL pesticide fate**
- deposition application
- dissipation at the crop canopy
- volatilisation
- wash-off
- injection
- pesticide uptake
- transformation solid-liquid gas partitioning
- convection dispersion diffusion
- leaching

**Groundwater depth**
(4 classes)

**Soil map**
(536 units)

**Land-use**

**Legende**
- Selectie Gebieden
- Klassen Grundwassertiefe
- 1
- 2
- 3
- 4

**Legende**
- Landgebruik
- niet residentieel groen
- tuin
- struikgewas
- fruit en noten
- gras
- veldbegroeid
Tool will follow a hybrid approach with a combination of process-based calculations for leaching to groundwater and indices for the vulnerability of the saturated zone.

**Indices for subsoil vulnerability**

- **P90-concentrations over 20-yr period**

- **Concentration (μg/L)**
  - 0.000041 - 0.01
  - 0.011 - 0.1
  - 0.11 - 0.61
  - Missing

- **Leaching concentrations**

- **Thickness of phreatic layer**

- **Conductivity of phreatic layer**

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RESULTS

Flanders-scale

Example:

- Vulnerability of phreatic groundwater in Flanders for pesticide x
- Settings: properties of pesticide x (molmas, Koc, DT50, ..) and typical application dose and time, applied on entire Flanders as if maize

P90
Leaching concentration

Classified with indices saturated zone
groundwater-vulnerability class
CONFRONTATION WITH MONITORING DATA

» Semi-quantitative approach comparing the spatial distribution of vulnerable and less vulnerable zones with spatial distribution of findings (measurement above LOQ) of pesticides

» VMM monitoring data:
  » period 2006 to 2014
  » 698 filters; 8000 samples; 56 pesticides
  » in 16% of the measurements one or more pesticides detected
CHLORIDAZON

Mobile, non-persistent

[Map and histogram showing distribution and concentration levels of Chloridazon]
LINURON

*Not mobile, non-persistent*
VIS-01 (METABOLITE OF CHLORTHALONIL)

Mobile, persistent
LOCAL SCALE: EXPLANATION OF FINDINGS

» Three selected wells with exceedances or elevated concentrations over a longer period of time; focus on maize herbicides

» Analysis of findings based on:
  » Monitoring data
    » Measured concentrations
    » Setting in the landscape, groundwater levels
  » Delineation of infiltration area of wells
    » Analysis of land-use
    » Farmer survey for actual use and agricultural practices
DELINEATION OF INTAKE AREA

Based on:
1. Groundwater flow direction
2. Length capture zone calculated based on
   » Filter depth
   » Thickness phreatic layer
   » Distance to water divide

GAMACTT (v1.0)
Böhlke et al., 2014

(Vandervelpen et al., 2011)
WELL NUMBER 1 - LEEST

- Frequent exceedances for S-metolachlor and terbuthylazine of the 0.1 µg/l threshold over the last 10 years
- Shallow groundwater (1.3 mbgl on average)
- Flat topography: small intake area (radius<100 m) and inconclusive information on groundwater flow direction
WELL NUMBER 1: VULNERABILITY

- Site vulnerability for SMOC and TBA is low (class 1)
- Realistic worst-case scenario considering yearly application of the substance
- Local settings of soil and climate are unlikely to explain the measured concentrations
- Substances reach the well through a fast route such as drainage systems
WELL NUMBER 2 - WAASMUNSTER

- Elevated concentrations for S-metolachlor-ESA; exceedances for bentazon in period 2007-2009
- Shallow groundwater (0.84 mbgl on average)
- Flat topography: small intake area (radius<100 m) and inconclusive information on groundwater flow direction
WELL NUMBER 2: ANALYSIS OF USE

Legend
SMOC
- geon data
- 0
- 1
- 2
- 3
- 4
- 5

Map showing areas with different numbers and color codes.

Bar chart showing crop analysis from 2012 to 2016.

Legend for bar chart:
- Maize
- Winter wheat
- Potatoes
- Grassland
WELL NUMBER 2: VULNERABILITY

- Calculated site vulnerability for SMOC is class 4
- Site vulnerable for leaching because of the sandy soil and high groundwater table
- Leaching through soil can be considered at least partly responsible for the high concentrations found (supported by the exceedances found in the past for bentazone)
- No direct indication of anomalies related to the use of SMOC (one incident reported of cleaning of a sprayer in the river)
WELL NUMBER 3 - KRUISHOUTEM

- Elevated concentrations for S-metolachlor-ESA; exceedances for bentazon in period 2006 to now
- Shallow groundwater (1.1 mbgl on average)
- Distinct topography: large intake area (length~1 km) and groundwater flow downhill
WELL NUMBER 3: ANALYSIS OF USE
WELL NUMBER 3: VULNERABILITY

- Delineated intake area much larger comprising 36 fields
- Calculated site vulnerability for SMOC is class 6
- Site vulnerable for leaching because of the sandy soil and the shallow groundwater table
- Leaching through soil can explain at least partly the exceedances (supported by exceedances found for bentazone) and given the large intake area for the well this can persist for a long period of time
- No indication good agricultural practices are not observed; not all farmers could be reached
CONCLUSIONS

Can vulnerability maps explain pesticide findings in groundwater?

» Groundwater vulnerability maps are useful to screen out wells with potential elevated concentrations and to design monitoring

» To accurately assess the situation around a particular well, local factors (intake area, land-use, use) need to be taken into account
Thank you