

## EFFECT OF AGGREGATION OF SOIL PARAMETERS IN SPATIALLY-DISTRIBUTED PESTICIDE LEACHING ASSESSMENTS

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### ABSTRACT

Spatially-distributed pesticide leaching models are now commonly used in pesticide registration and policy evaluation. In the Netherlands, the GeoPEARL model is used to calculate the regulatory endpoint, which is the 90th spatial percentile of the leaching concentration. To get an accurate estimate of this spatial percentile, the model must be run for a large number of unique combinations of soil type, weather district and groundwater depth group. In the current GeoPEARL schematisation, these unique combinations are aggregated to 6,405 larger spatial units. Within each unit the dominant soil profile is assumed to be representative for the whole unit. We tested the effect of this spatial aggregation on nationwide predictions of pesticide leaching. Based on the soil map 1:50,000, each unit was subdivided into sub-units with the same soil type. Soil profile descriptions were obtained for all spatial sub-units. In this way, a more detailed spatial schematisation with 48,233 unique combinations was obtained. GeoPEARL was run for four substances using both schematisations. Comparison of results shows a minor effect on the nationwide frequency distribution of the predicted leaching concentration for all substances. Also, the 90th percentile leaching concentration was hardly affected by spatial aggregation of soil type within larger spatial units. However, when the detailed and aggregated maps are compared on a pixel basis, 30-40% of the pixels showed differences greater than 25%. These findings indicate that the current GeoPEARL schematisation works well for predicting pesticide leaching on the regional to national scale, but that local prediction is meaningfully affected by spatial aggregation of soil parameters.

**KEY WORDS:** leaching, groundwater, aggregation procedures

### INTRODUCTION

Spatially-distributed pesticide leaching models are now commonly used in pesticide registration and policy evaluation. In the Netherlands, the GeoPEARL model is used to calculate the regulatory endpoint, which is the 90<sup>th</sup> spatial percentile of the leaching concentration. To get an accurate estimate of this percentile, GeoPEARL is run for a large number of unique combinations of soil type, weather district and groundwater depth group (Tiktak *et al.*, 2002). The current GeoPEARL version uses the so-called STONE schematisation, which was originally developed for national predictions of nutrient emissions to surface waters and groundwater (Kroon *et al.*, 2001). In this schematisation, the unique combinations are aggregated to 6,405 larger spatial units, using relation diagrams (see also Tiktak *et al.*, 2003b). Within each unit, the dominant soil profile is assumed to be representative for the whole unit. We tested the effect of this assumption on nationwide predictions of pesticide leaching. Two output parameters were analysed in detail, i.e.:

- the regulatory endpoint for the GeoPEARL model, which is the 90<sup>th</sup> spatial percentile of the leaching concentration;
- spatial patterns of the leaching concentration.

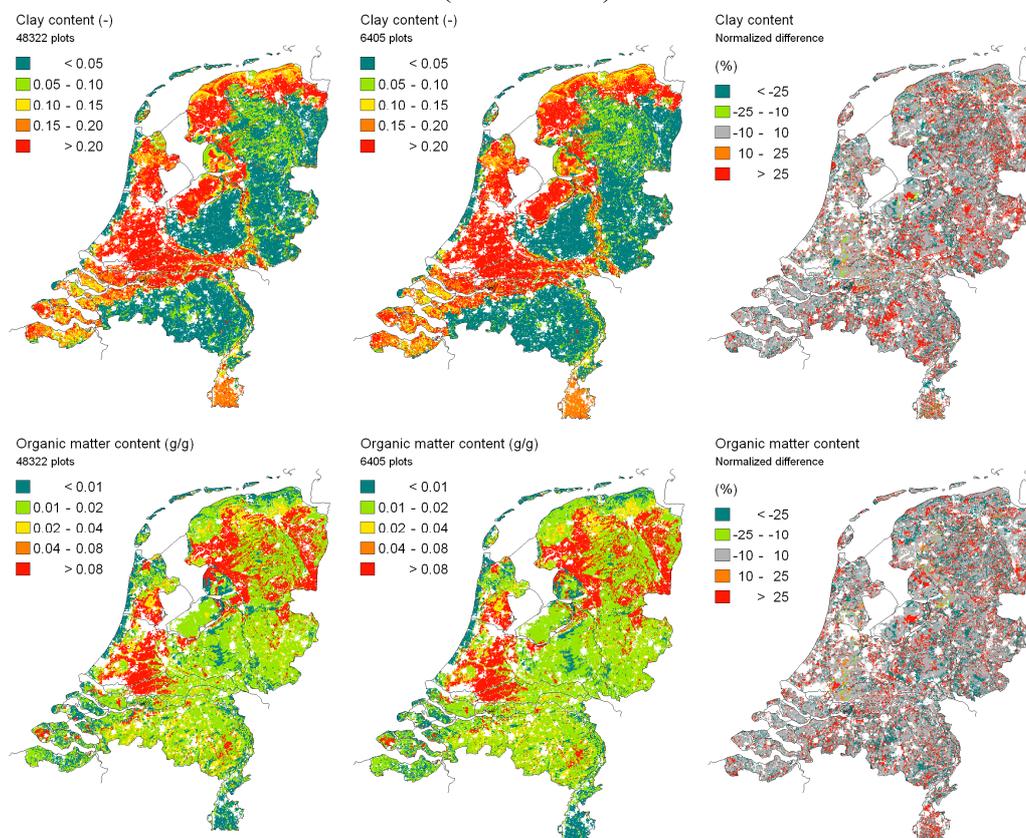
## MATERIALS AND METHODS

To create a more detailed spatial schematisation, the map of unique combinations in GeoPEARL was overlain with the Soil Map of the Netherlands 1:50000. This soil map contains 330 different so-called soil chemical map units (De Vries, 1999). Each of these map units is associated with a representative profile description, which is described in terms of a vertical succession of pedogenetic soil horizons. Each pedogenetic soil horizon is described by median values for thickness of soil horizon, organic matter content, textural distribution, *pH*-KCl, and soil bulk density. Also included are statistics of the spatial variation of these properties. These statistics are derived from point-data in the Soil Information System of Alterra.

The overlay of the 1:50000 soil map and the GeoPEARL schematisation resulted in a new schematisation with 48423 unique combinations. Basic soil properties for GeoPEARL, like textural distribution and organic matter, were directly derived from the 330 soil profile descriptions of the associated soil chemical map. To determine the Mualem-van Genuchten parameters, a classification tree has been constructed. Given the soil texture, organic matter content and the geological formation, the Staring series building block can be determined, as well as its associated Mualem-van Genuchten parameters.

Figure 1 shows a map of the clay content and organic matter content of the upper 1.2 meter of the soil profile as derived from the original map with STONE-plots and as derived from the new soil chemical-physical map. At first glance, differences between the two maps are small. A closer look, however, shows that there are considerable differences up to 25% (Figures to the right).

Figure 1: Clay content and organic matter content of the upper 1.2 m of the soil profile according to the map with STONE-plots (6405 units) and according to the new soil chemical-physical map (48423 units).



GeoPEARL was run for four substances. Properties of these substances are described in table 1. Substances NLA-NLD are described in FOCUS (2000). Substance NLE shows *pH*-dependent sorption behaviour, and is described in Van der Linden *et al.*, 2001. The substances were annually applied to the soil surface in spring (26 May). Assessments were made for both the detailed schematisation, and the original STONE schematisation.

Table 1: Overview of the most important properties of the pesticides considered in this study.

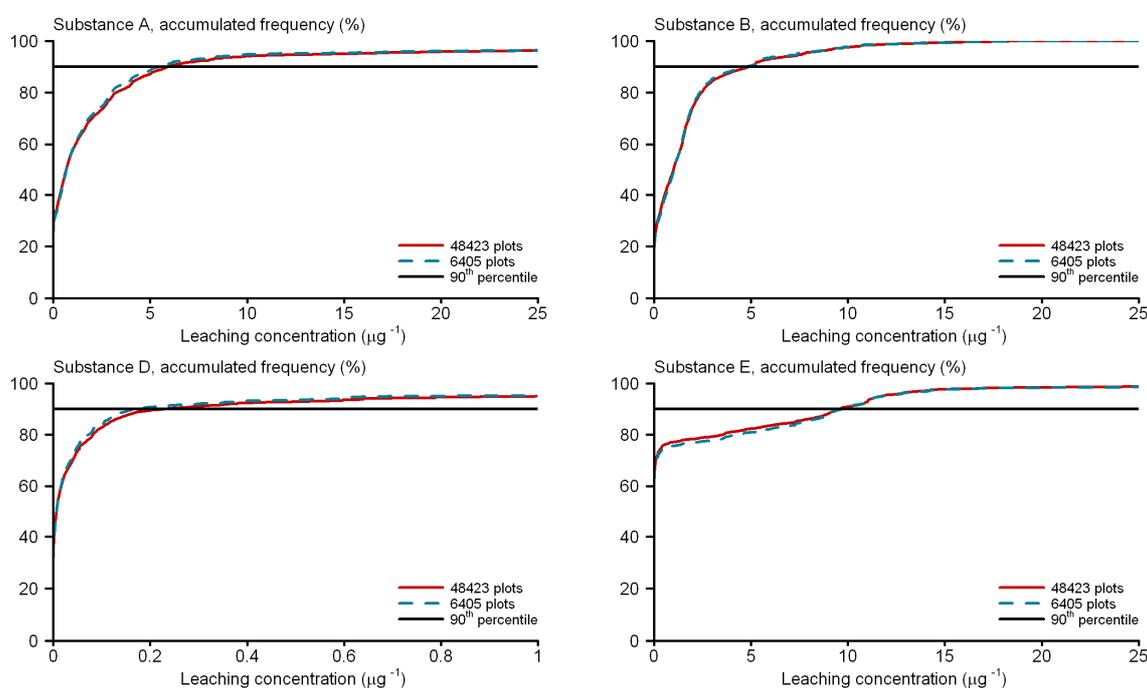
Property <sup>1</sup>	NLA	NLB	NLD	NLE
$M$ (g mol <sup>-1</sup> )	300	300	300	200
$P_{v,s}$ (Pa)	0	0.0001	0.0001	0
$S_w$ (mg L <sup>-1</sup> )	90	90	90	50
$K_{om,ac,eq}$ (L kg <sup>-1</sup> )	60	10	35	500
$K_{om,ba,eq}$ (L kg <sup>-1</sup> )	60	10	35	25
$K_{om,ne}$ (L kg <sup>-1</sup> )	-	-	-	-
<i>pKa</i>	-	-	-	4.5
$DT_{50,ref}$ (d)	60 (20 °C)	20 (20 °C)	20 (15 °C)	50 (20 °C)
$k_d$ (d <sup>-1</sup> )	0	0	0	0

1)  $M$  is the molar mass,  $P_{v,s}$  is the saturated vapour pressure,  $S_w$  is the solubility in water,  $K_{om,ac,eq}$  is the coefficient of equilibrium sorption on organic matter under acidic conditions,  $K_{om,ba,eq}$  is the coefficient of equilibrium sorption on organic matter under basic conditions,  $K_{om,ne}$  is the coefficient of sorption to the non-equilibrium domain, *pKa* is the negative logarithm of the dissociation constant,  $DT_{50,ref}$  is the half-life under reference conditions, and  $k_d$  is the rate constant for non-equilibrium sorption.

## RESULTS

Comparison of results shows a minor effect on the nationwide frequency distribution of the predicted leaching concentration for all substances. Also, the 90<sup>th</sup> percentile leaching concentration was hardly affected by spatial aggregation of soil type within larger spatial units (figure 2).

Figure 2: Cumulative frequency distribution of the leaching concentration of four substances (see table 1 for substance properties) calculated with the original STONE schematisation (6405 plots) and the detailed spatial schematisation (48423 plots).



Results were also compared on a pixel basis (gridcell size 250x250 m<sup>2</sup>). The variable under consideration is the median value of the annual leaching concentration, which is the target variable in the new Dutch decision tree on pesticide leaching (Van der Linden *et al.*, 2004). Results are shown in figure 3. A first comparison of the spatial patterns does not show systematic regional trends. However, when evaluating the normalized differences between the two schematisations, meaningful differences are found (righthand side of 3). The normalized difference, *ND*, is calculated as follows:

$$ND = 100 \frac{c_{L,StonePlus} - c_{L,Stone}}{c_{L,StonePlus}} \quad (1)$$

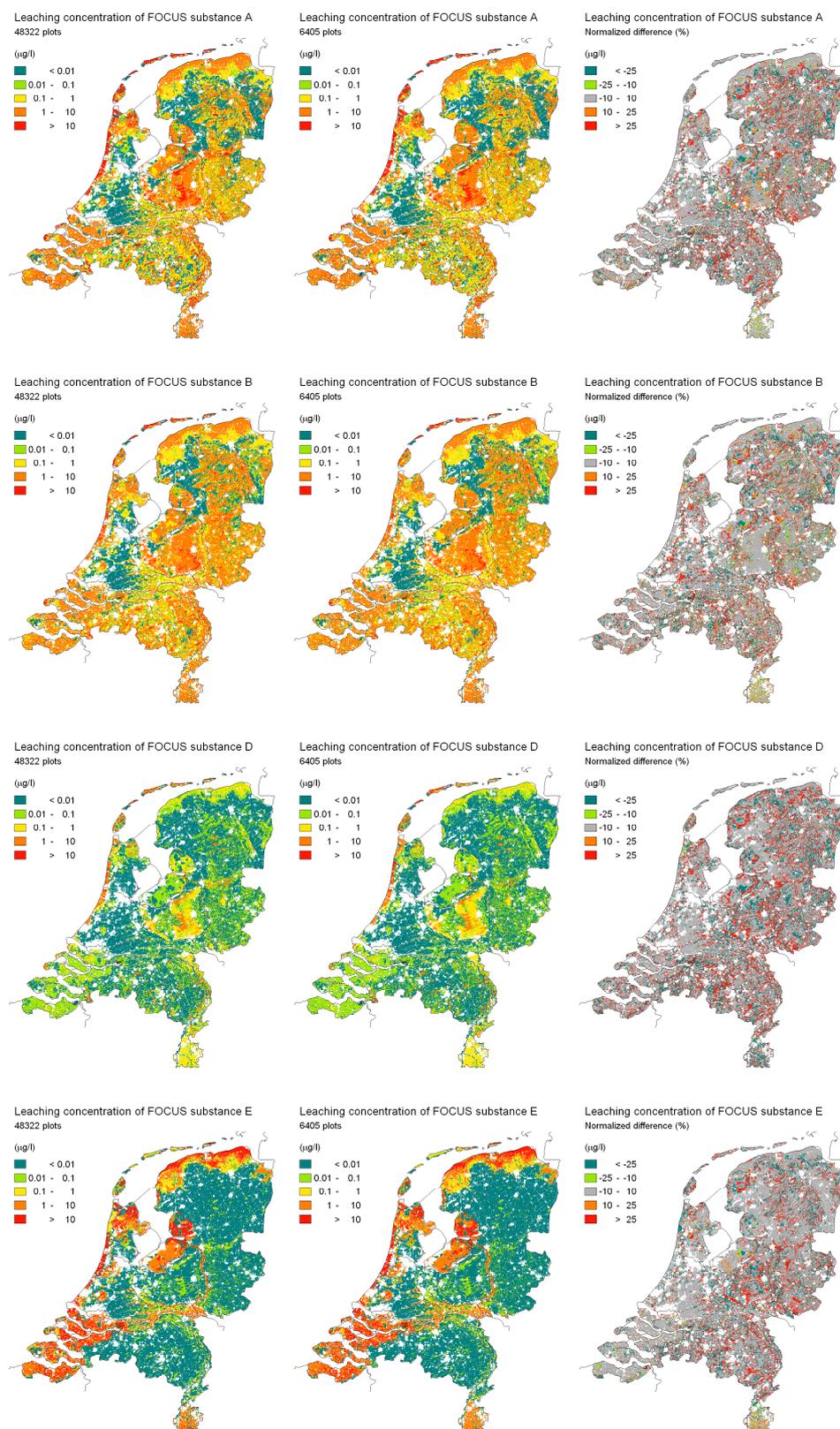
A frequency distribution of the normalized difference shows that 30-40% of the pixels show differences greater than 25% (table 2).

Table 2: Frequency distribution of the normalized difference between the maps presented in figure 2.

ND <sup>1</sup>	NLA	NLB	NLD	NLE
< -25 %	16	15	20	16
-25 - -10 %	2	3	0	1
-10 - +10 %	62	63	60	67
+10 - + 25 %	3	4	0	1
> + 25 %	17	15	20	15

1) calculated according to equation 1

Figure 3: Predicted median value of the annual leaching concentration of four example substances at 1-m depth. An annual pesticide dosage of 1 kg ha<sup>-1</sup> was used. Left: Detailed schematisation, middle: Original STONE schematisation, right: normalized difference (%).



## CONCLUSION

The current GeoPEARL schematisation appears to be sufficient for predicting pesticide leaching on the regional to national scale. Local scale predictions are, however, meaningfully affected by spatial aggregation of soil parameters. This conclusion is in line with earlier conclusions regarding the STONE hydrology (Tiktak *et al.*, 2003a), who advised not to use the STONE schematisation for spatial scales smaller than 25 km<sup>2</sup>.

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