The Dutch decision tree for pesticide leaching to groundwater

Jos Boesten

CONTRIBUTIONS BY

RIVM

TON VAN DER LINDEN

JAN LINDERS

AALDRIK TIKTAK

ANJA VERSCHOOR

ALTERRA

JOS BOESTEN

ROEL KRUIJNE

MINZE LEISTRA

CTB

ADI CORNELESE

WERNER POL

Outline

Introduction

Vulnerability concept

Overview of decision tree

Tier 1

Tier 2

Tier 3

Introduction

- old decision tree from 1989:
based on 1 standard scenario selected via expert judgement

- development of new tree started in 1999

- consensus process via workgroup (RIVM, Alterra, CTB)

-- current views: no political decision on introduction yet
(expected in April/May)

Introduction

General aim:
protection of groundwater for use as drinking water

Most public wells 20-30 m deep and water abstraction rate above 10^6 m^3 per year

Scientific operationalisation in tree:
90^{th} percentile of concentration at 10 m depth
in area of use below or above 0.1 μg/L ?

Introduction

General principles in decision tree:

1. earlier steps more strict than later steps

2. earlier steps require usually less efforts than later steps (exhaust first modelling possibilities before requiring additional experimental studies)

3. same target quantity in all steps (90th percentile)

4. jumping to later steps usually acceptable

5. willingness to accept any relevant information

Vulnerability concept

Dutch considerations:

- drinking water

- extracted water is mixture of many years so long-term average most important

- preferable to protect a larger surface area on long term than a smaller surface area against too high peak concentrations

Vulnerability concept

proposed Dutch procedure:

- long-term average of pesticide concentration leaching below 10 m depth (e.g. averaged over 20 years)

- 90^{th} percentile in area of use considering:
  - variability in soil profile properties
  - variability in groundwater levels
  - variability in climate
  - area of use via selection of crop
  - application rate and time of pesticide
  - mean or median pesticide properties

Vulnerability concept

- median concentration with time
  - basis: yearly averages
  - median is more robust than average

- 90^{th} percentile concentration in space

Overview decision tree

1

calculations with FOCUS Kremsmünster

2

- calculations with GeoPEARL

- additional field/lysimeter/laboratory experiments to improve estimations with GeoPEARL
- monitoring shallow groundwater

1 m

3

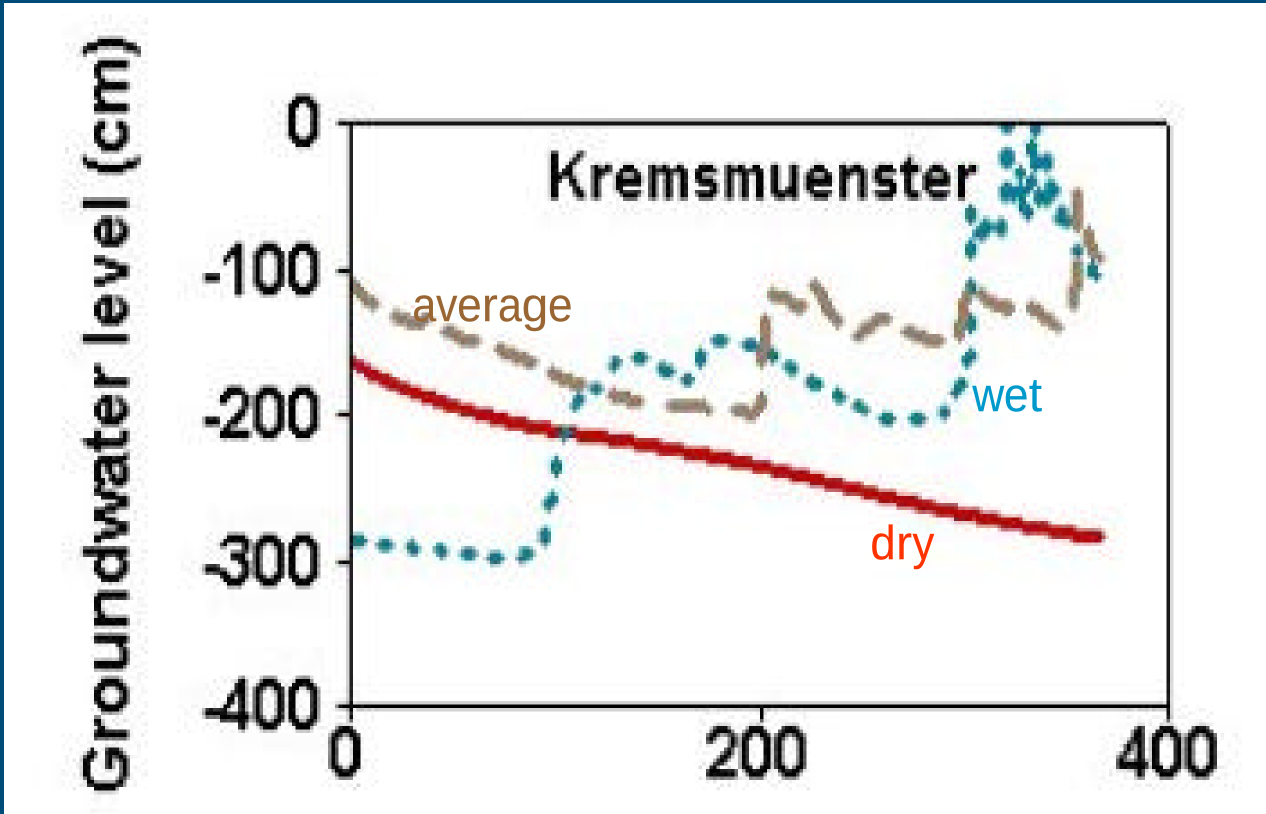
- transformation rate in water-saturated zone
- monitoring deep groundwater

Tier 1

- criteria:
  # as simple as possible
  # more strict than Tier 2 but not too protective
  # use existing FOCUS scenario

- possible FOCUS scenarios:

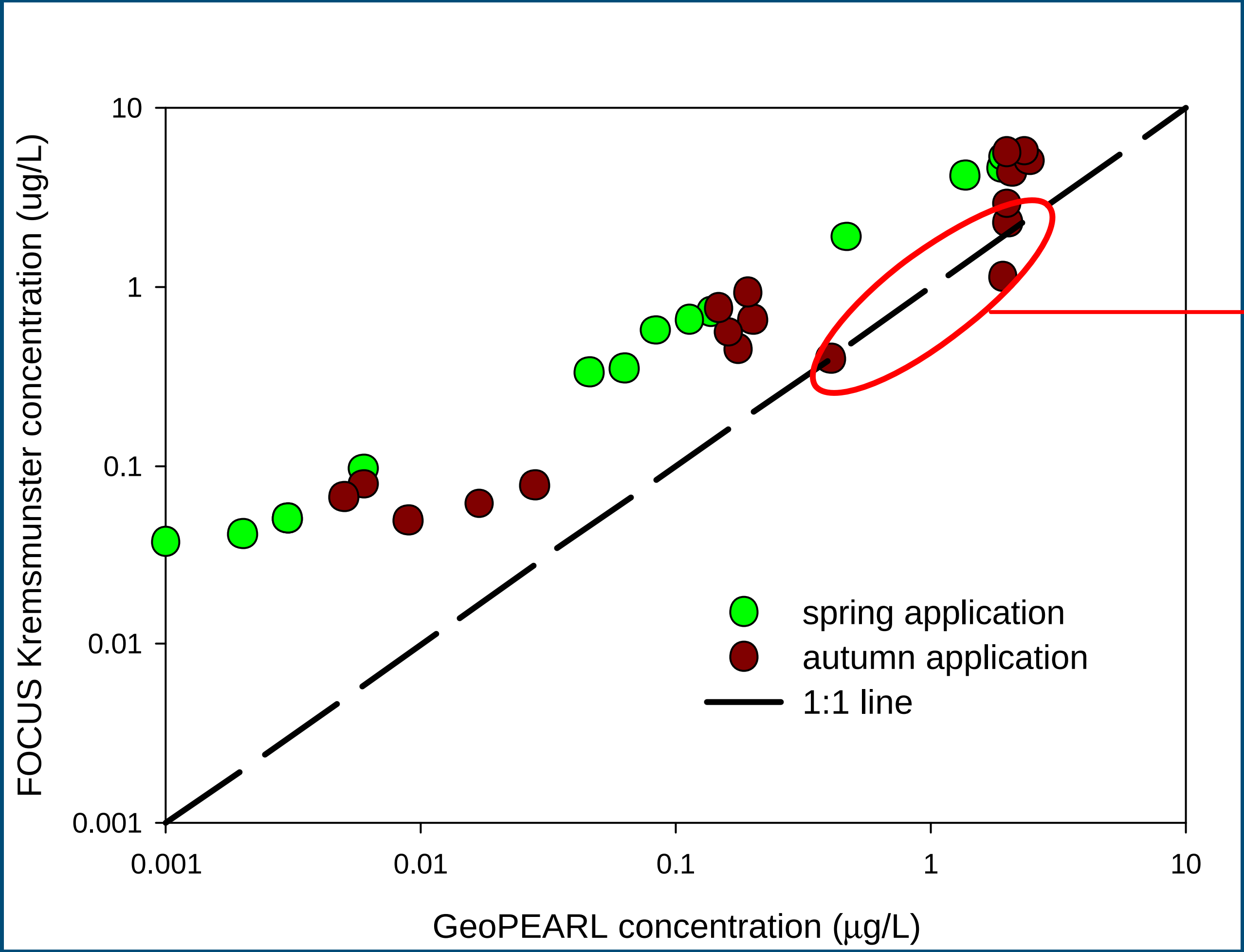
Chateaudun
Hamburg
Kremsmünster
Okehampton



Time (d)

potatoes

Kremsmünster: groundwater level within profile



K_{om} < 10 L/kg
DegT50 < 10 d

Kremsmünster: strict enough with few exceptions

Tier 2

90^{th} percentile of area of use in
(a) Dutch agriculture < 0.1 µg/L
(b) drinking water protection areas < 0.01 µg/L
in GeoPEARL calculations ?

field or lysimeter studies result in safe 90^{th} percentile ?

more realistic half-lives result in safe 90^{th} percentile ?

monitoring shallow groundwater

Special protection for drinking water abstraction areas

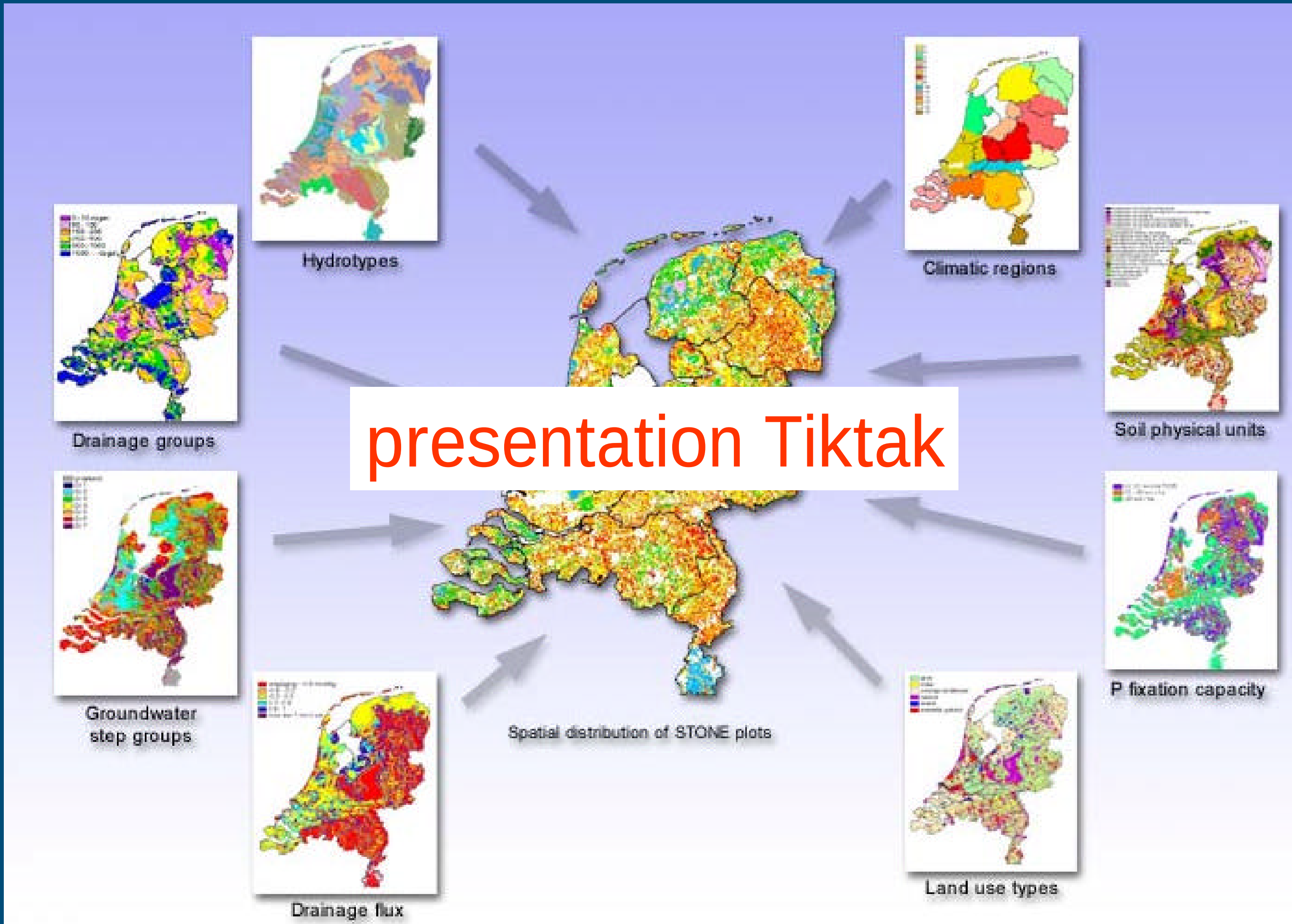
- GeoPEARL calculations for drinking water abstraction areas showed higher vulnerability

Pragmatic solution:

- if GeoPEARL 90th percentile for whole area of use

  > 0.01 ug/L, then do not use in these abstraction areas unless notifier demonstrates safety

Estimation of 90th percentile in area of use via GeoPEARL



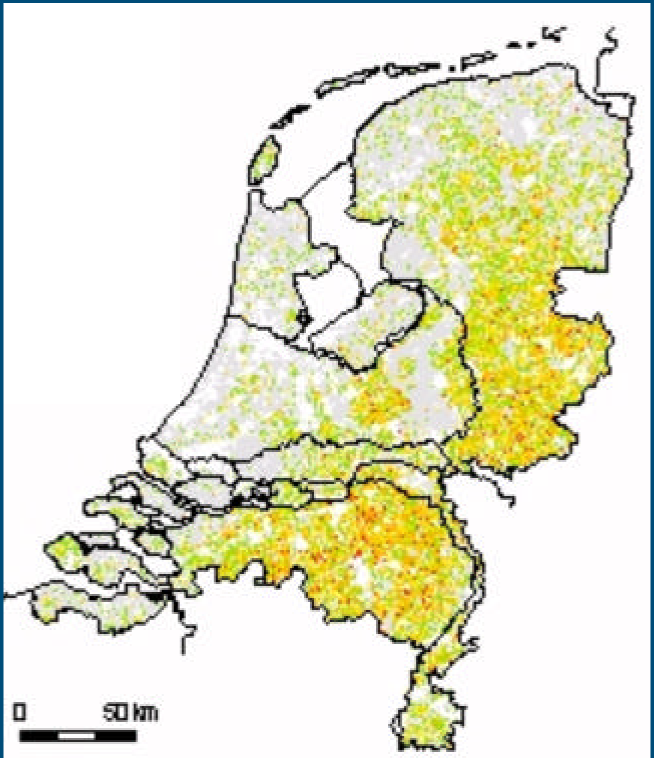
Tier 2: field/lysimeter studies

1 m^2

lysimeter

extrapolation problem

200 000 ha



area of use

Tier 2: field/lysimeter studies

- principle: PEARL model may be wrong

- field/lysimeter results are used to calculate simulation error SE:

SE = simulated leaching / measured leaching

- correct estimated 90th percentile concentration by SE

(see Verschoor et al.)

Tier 2: additional transformation rate studies with topsoil

- GeoPEARL starts with one DT_{50} for all 5000 plots

- estimated 90th percentile more reliable if DT_{50} more reliable

- uncertainty in DT_{50} leads to low accuracy of leaching maps

Tier 2: additional transformation rate studies with topsoil

- additional transformation rate studies with e.g. 10 representative Dutch topsoils or available evidence on soil- DT_{50} relationships from other data may lead to better DT_{50} estimates

GeoPEARL:

$DT_{50} = a_0 + a_1\ OM + a_2\ pH + a_3\ Clay$

- more consistent with “area of use” aim than lysimeter (invest in range of soils instead of in 1 m^2 of 1 soil)

- calculate revised 90th percentile with GeoPEARL using improved estimation of DT_{50}

Tier 2

90th percentile of area of use in
(a) Dutch agriculture < 0.1 µg/L
(b) drinking water protection areas < 0.01 µg/L
in GeoPEARL calculations ?

field or lysimeter studies result in safe 90th percentile ?

more realistic half-lives result in safe 90th percentile ?

monitoring shallow groundwater

Tier 2: monitoring shallow groundwater

Statistical null hypothesis:

90^{th} percentile in space of long-term average concentration exceeds 0.1 μg/L

Procedure:

report by Cornelese et al.

90th percentile in shallow groundwater

Tier 3

transformation rate studies with four water-saturated subsoils

estimated concentration at 10 m depth results in safe 90th percentile ?

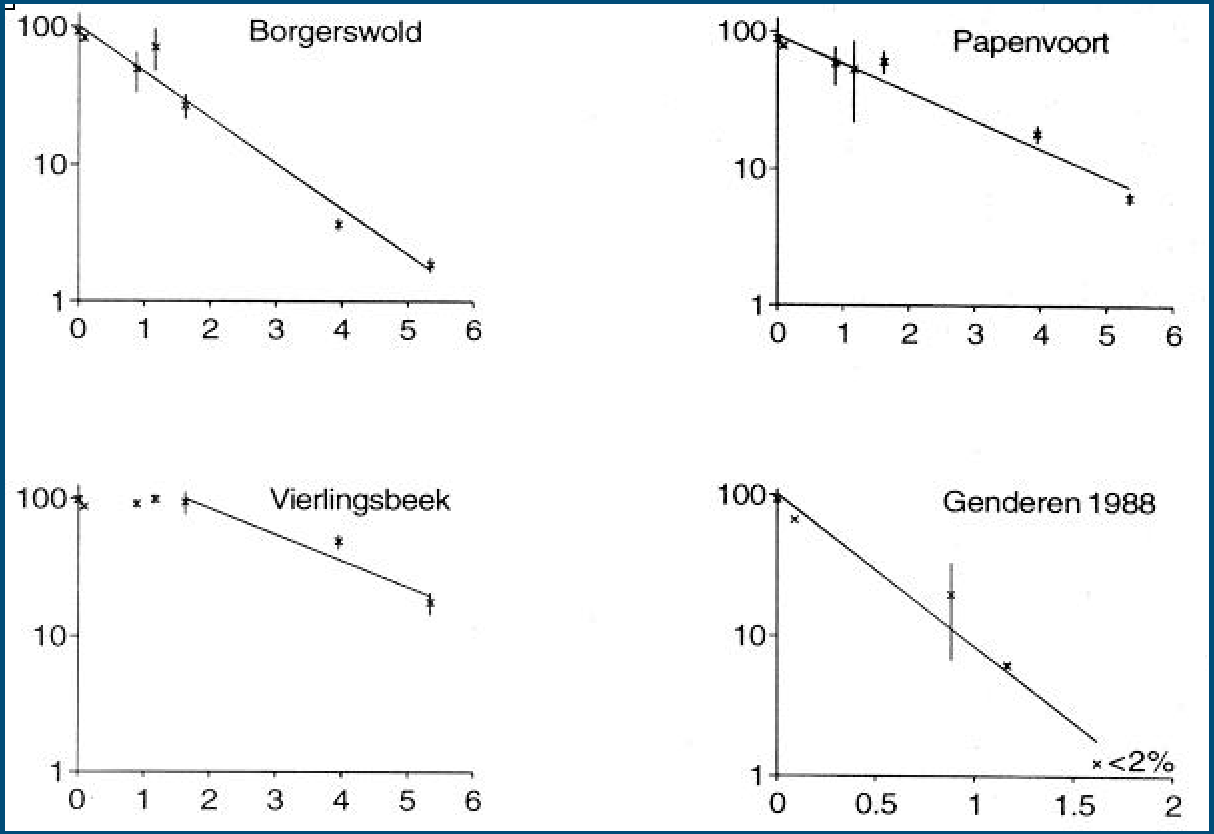
monitoring deep groundwater

END

Tier 3: behaviour in water-saturated zone

example: atrazine

% of dose



time (years)

Van der Pas et al. 1998 Pestic Sci 53: 223-32

Tier 3: behaviour in water-saturated zone

Calculation procedure of concentration at 10 m depth:

- assume travel time of water of 4 year (on safe side)

- assume first-order transformation kinetics

90th percentile in shallow groundwater

↓

Tier 3

transformation rate studies with four water-saturated subsoils

↓

estimated concentration at 10 m depth results in safe 90th percentile ?

↓

monitoring deep groundwater

↓

END

Tier 3: monitoring deep groundwater

Statistical null hypothesis:
90^{th} percentile of all relevant sampling wells exceeds 0.1 μg/L

Argument: only sampling wells considered (no wells pumped for drinking water), so 90^{th} perc. sufficient to protect drinking water

Procedure:

complicated story: non-relevant positives and negatives
false positives and negatives

report by Cornelese et al.

90th percentile in shallow groundwater

Tier 3

transformation rate studies with four water-saturated subsoils

estimated concentration at 10 m depth results in safe 90th percentile ?

monitoring deep groundwater

END

rivm

ctb

ALTERRA
WAGENINGEN UR