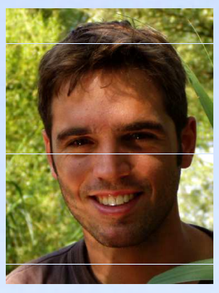
# Determination of denitrification capacity of small headwater catchments in Flanders

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## 1. Background & Objectives

- **Nitrate pollution** is a severe problem in **Flanders**, Belgium:
  - **Nitrate** ($NO_3^-$) concentration in many surface water bodies **exceeds** maximum concentration of 50 mg $NO_3^- L^{-1}$ (**EU Nitrates Directive**, 91/676/EEC).
  - **In 2010: 28%** of **surface water sampling points** of MAP-network **exceeded** this **limit** at least once a year (VMM, 2010) (Figure 1).
- Important **cause** of nitrate pollution: Nitrate **leaching** from **agricultural parcels**
- During **transport** of **leached nitrate** to groundwater and surface water: **denitrification processes**.

→The **process factor (PF)** comprises all **denitrification processes** between **leaching** of nitrate and **immission** to water bodies:

$$PF = [NO_3^-]_{\text{Soil leachate at -90 cm}} / [NO_3^-]_{\text{Surface water}}$$

Objective: - **Determination** of the **environmental variables** controlling the denitrification capacity of small headwater catchments in Flanders
- **Regional differentiation** of the **process factor** is defined.

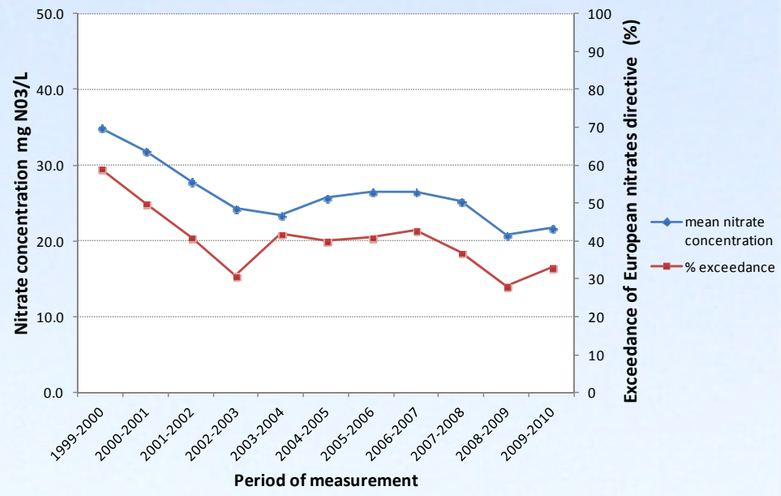


**Figure 1 - Evolution of water quality in small headwater catchments in Flanders (2000-2010)**
Source: VMM, 2010

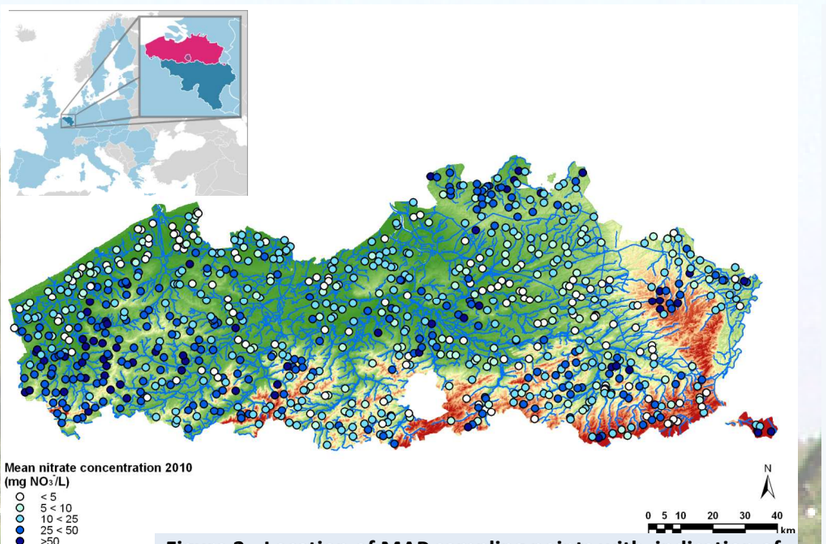


**Figure 2 - Location of MAP sampling points with indication of mean nitrate concentration in 2010**

## 2. Materials & Methods

- Delineation of **794 catchments** for the sampling points of the MAP network with ArcSWAT GIS software (Neitsch et al., 2009).
- Selection of **50 best catchments**:
  - homogeneity of **soil**
  - homogeneity of **hydrogeological** properties
  - **no residential sewage**
- Modelling of **nitrate leaching** (**A**) from all parcels within a catchment (4 subsequent years)
- Calculation of mean **nitrate concentration at outlet** of catchment (**B**)
- Determination of **process factors**, (**A/B**) i.e. the denitrification capacity: ratio of area-averaged **nitrate concentration** of the **leachate** in each catchment over the mean **nitrate concentration i**n the **corresponding surface water sampling point**

## 3. Results & Discussion

- **Process factor values** ranged from 0.9 to 104.4
- **Soil granulometrical class** of the catchment and **redox potential** of the underlying aquifer → main significantly **explanatory variables** of the process factor.
- **Predictive regression model** for the transformed process factor (Box-Cox transformation, λ = -0.5)

$$PF_t = A + 0.001943 \quad \text{redox potential (mV)} \qquad (n = 47, R^2 = 0.39)$$

*sand: A = -1.270  sandy loam: A = -1.241  silt: A = -1.650  clay: A = -1.433*

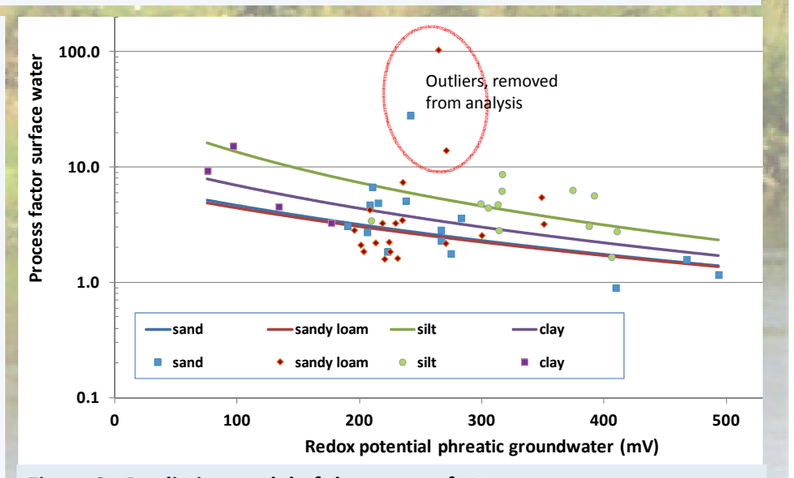


**Figure 3 - Predictive model of the process factor**

- **Full coverage predictive maps** for Flanders region based on the **digital soil map** and a geodataset of the **redox potential** of the phreatic aquifer.
- Clear **regional variation** of predicted process factor:
  - → values of **1.3** in the **East** (deep sandy soils with high redox potential) to **12** in the **West** (shallow estuarine clayey soils with low redox potential)
  - → Some regions are very **prone to nitrate pollution**

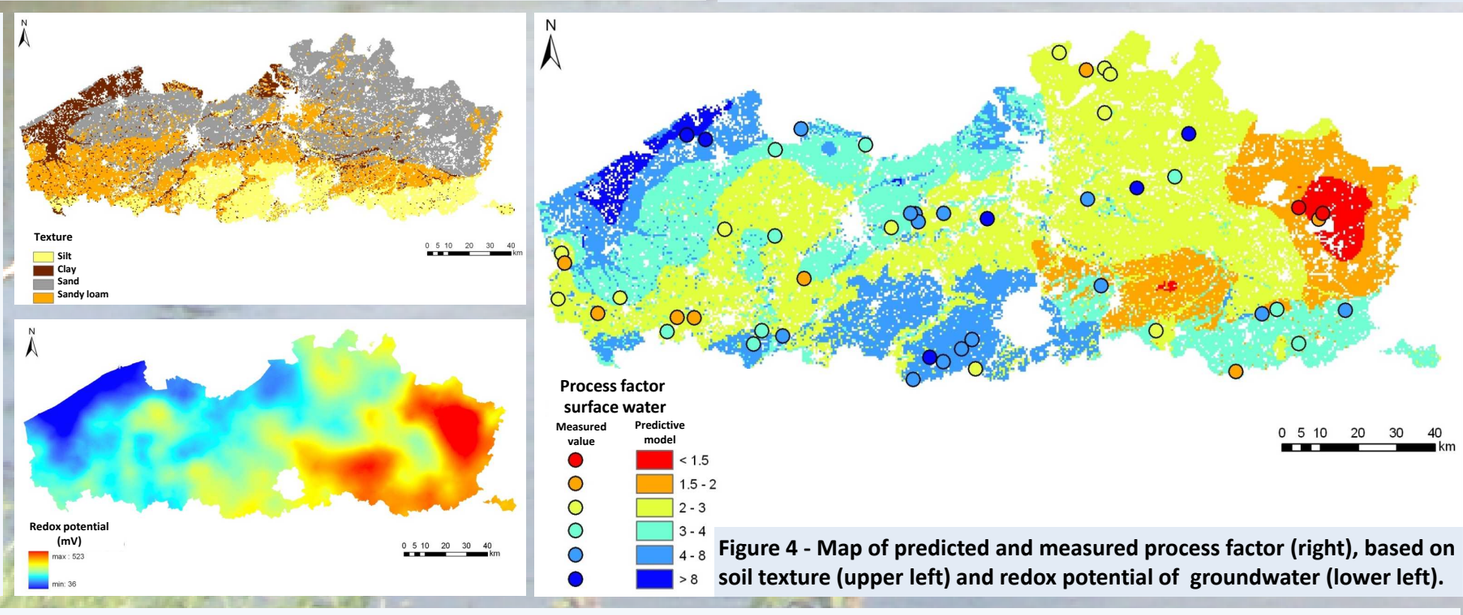


**Figure 4 - Map of predicted and measured process factor (right), based on soil texture (upper left) and redox potential of groundwater (lower left).**

## 4. Conclusions

This study investigated **factors determining** the **denitrification** capacity of **small headwater catchments** in **Flanders**. Results suggest that **soil texture** and **redox potential** of the aquifer are the **main explanatory variables**. A **predictive model** allowed for a regional **differentiation** of the denitrification capacity in Flanders. The resulting predictive **map** of the **process factor** could be used as a **tool** to evaluate the **vulnerability of surface waters** to **nitrate pollution**.

## 5. Cited literature


Neitsch S. L., Arnold J. G., Kiniry J. R., Williams J. R. 2009. Soil and Water Assessment Tool. Theoretical Documentation. Version 2009. Grassland, Soil and Water Research Laboratory, Blackland Research Center, Temple, Texas, USA.

VMM. 2010. Annual Report Water. Flemish Environmental Agency (VMM). 78pp.



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