Influencing factors on the nitrate residue levels in Flemish agricultural soils: a statistical analysis of 8 years of nitrate measurements


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1. Background & Objectives

In Flanders, nitrate residues in the soil profile are used as an indicator for the risk of nitrate leaching from agricultural soils to surface and ground water. The nitrate residue is defined as the amount of nitrate-N present in the soil profile (0-90cm) during the period October 1st to November 15th. They are measured annually, on one hand in a (more or less) directed selection of agricultural parcels (commissioned by the Manure Bank) and on the other hand in all the parcels having an agro-environmental agreement "Water" (AEA Water). This produces datasets of 18 000 up to more than 30 000 nitrate residue measurements per year.

In the framework of the assignment of the Flemish Government to evaluate and differentiate the current nitrate residue standard, an extensive review of the historical nitrate residue measurements was made.

This descriptive analysis had to provide an answer to the following questions:

- which factors have a significant influence on the nitrate residue levels?
- what are the impacts of policy measures such as stricter fertilisation standards, agro-environmental agreements, etc.?


Soil sampling for nitrate residue measurement

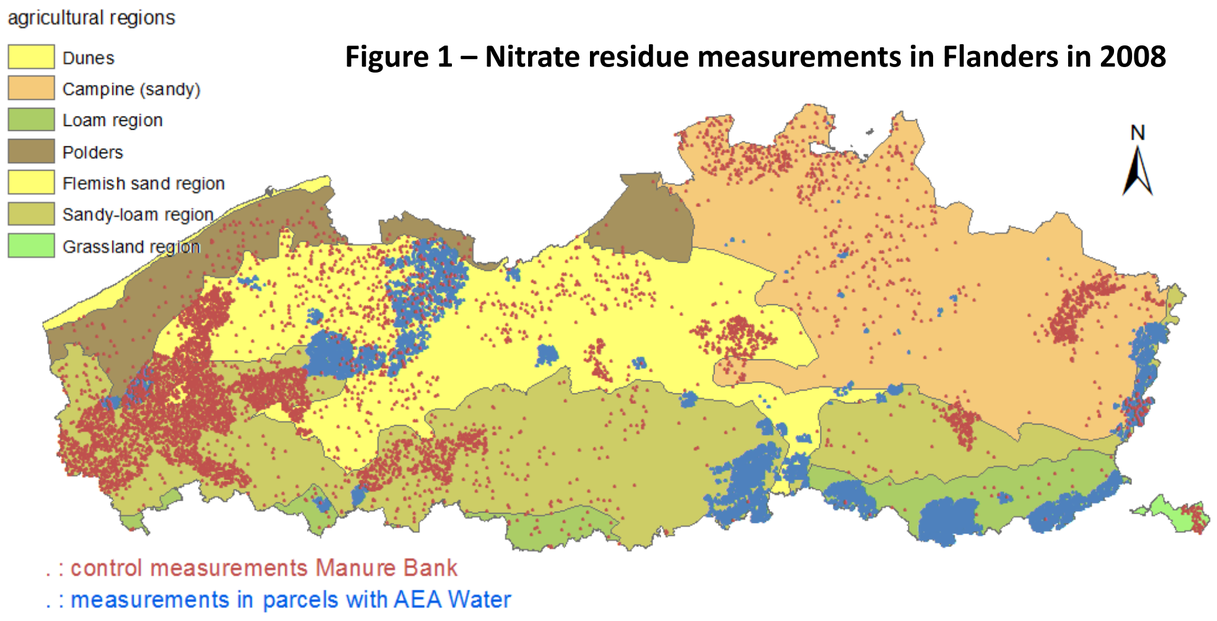

Figure 1 – Nitrate residue measurements in Flanders in 2008

2. Materials & Methods

Available datasets:

- Nitrate residue measurements: 2 datasets:
  - in parcels with AEA Water (2001-2008: 173 022 measurements)
  - control measurements (Manure Bank) (2004-2008: 35 916 measurements).
- additional information: sampling date, exact location of the parcel, main crop, catch crop (if present) and parcel surface.
- linked data: climatic conditions, soil conditions (soil type, carbon content, pH), crop rotations, fertilisation limits and data on farm level concerning fertiliser use and manure production.

Statistical analysis:

- log-transformation applied on the nitrate residue data in order to meet the statistical requirements of normality and homoscedasticity.
- analysis of the influence of the different parameters on the nitrate residues through AN(C)OVA, correlation and regression techniques.

3. Results & Discussion

- Significantly lower nitrate residues in parcels with AEA Water than in the parcels with control measurements: mainly caused by the applied fertilisation practices. In parcels with AEA Water, fertilisation is generally better tuned to crop needs and as a consequence, effects of other parameters are smaller.
- Significant decrease of nitrate residues over the years in both datasets: attributed to a combined effect of stricter fertilisation limits and a gradual adoption of these limits in the farming practice, increased attention of the farmers to manuring practices and a better follow-up of fertilisation advices.
- Significant effect of the crop type: grass and fruit trees show the lowest nitrate residues, followed by sugar beets. Potatoes and vegetables give on average the highest nitrate. Maize and cereals give intermediate values.
- Effect of catch crops: decrease of nitrate residues dependent of type of main crop and catch crop:
  - important after cereals (harvested relatively long before the soil sampling);
  - less pronounced after sugar beets and maize (harvested shortly before or even after the soil sampling);
  - more important with a catch crop yellow mustard than with grassy catch crops (slower initial growth).
- Significant and relatively important effect of the carbon content of the ploughing layer (0-30 cm) and significant interaction with soil pH and soil texture: nitrate residues increase with increasing soil carbon contents. With higher pH-values and in heavier soil textures (loamy and clayey soils), this increase is more pronounced.

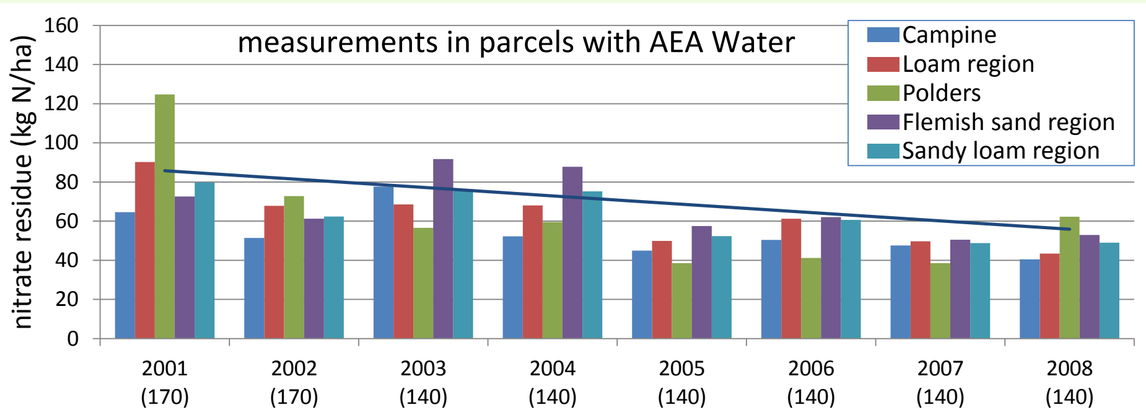

Figure 2 - Nitrate residue measurements (0-90 cm) over the years, in relation to fertilisation limits

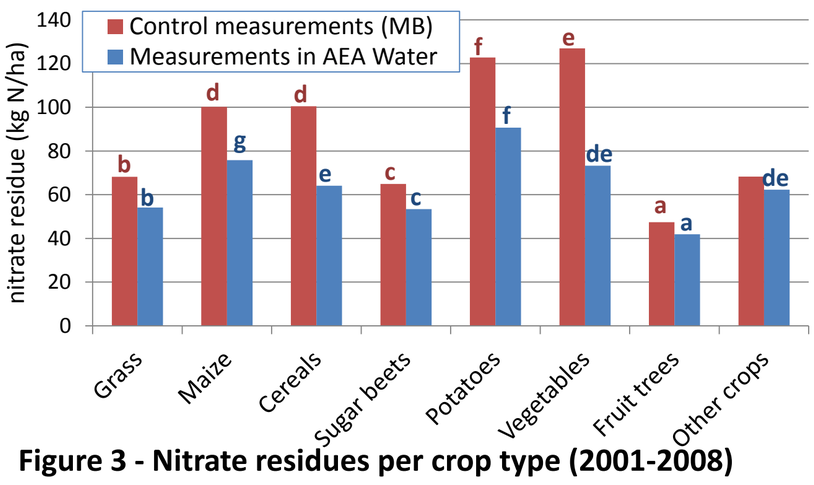

Figure 3 - Nitrate residues per crop type (2001-2008)

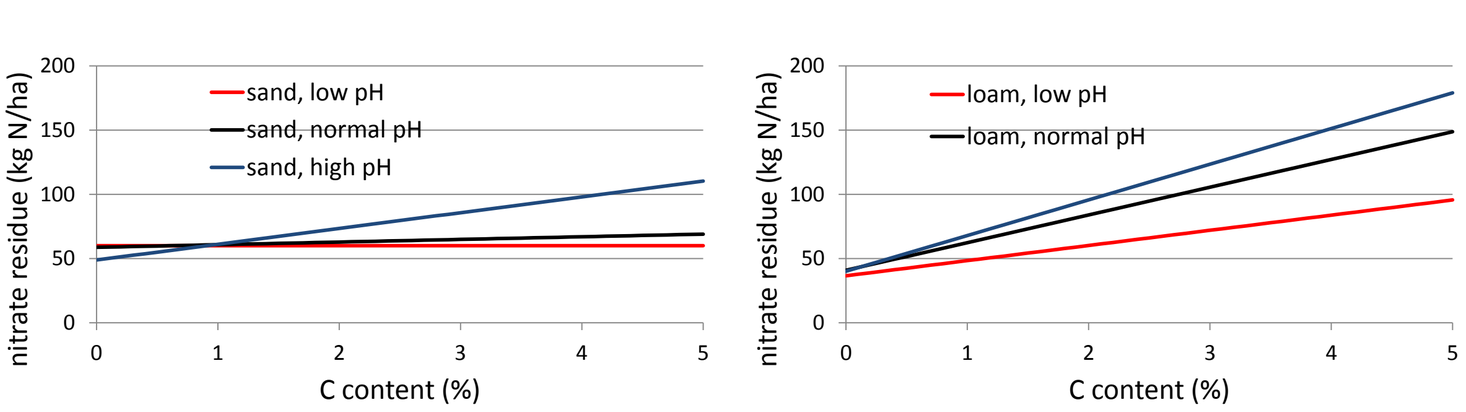

Figure 4 - Nitrate residue (0-90 cm) related to the carbon content of the top soil

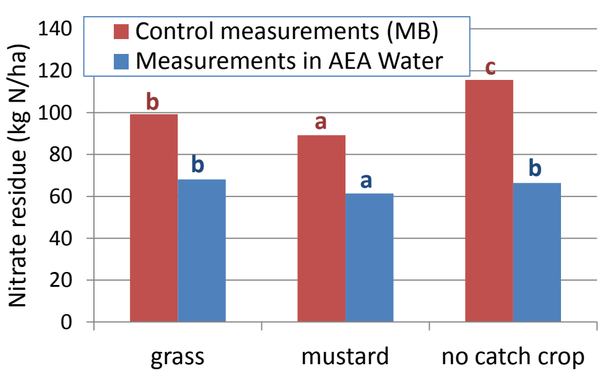

Figure 5 – Average effect of catch crops after winter wheat on nitrate residues

4. Conclusion

The extensive analysis of the available nitrate residue measurements in Flanders since 2001 demonstrates the importance of fertilisation practices and policy measures. Parcels with an AEA Water have to meet stricter fertilisation standards and as a consequence show lower nitrate residue levels. Moreover, in all the measurements a significantly decreasing trend is observed over the years, parallel to the evolution of fertilisation standards becoming stricter and farmers adopting more the principles of good fertilisation practices, such as the use of catch crops.

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