Modeling the soil moisture and mineral N balance to support advices for better farming practices. A case study in North-East Flanders (Belgium)

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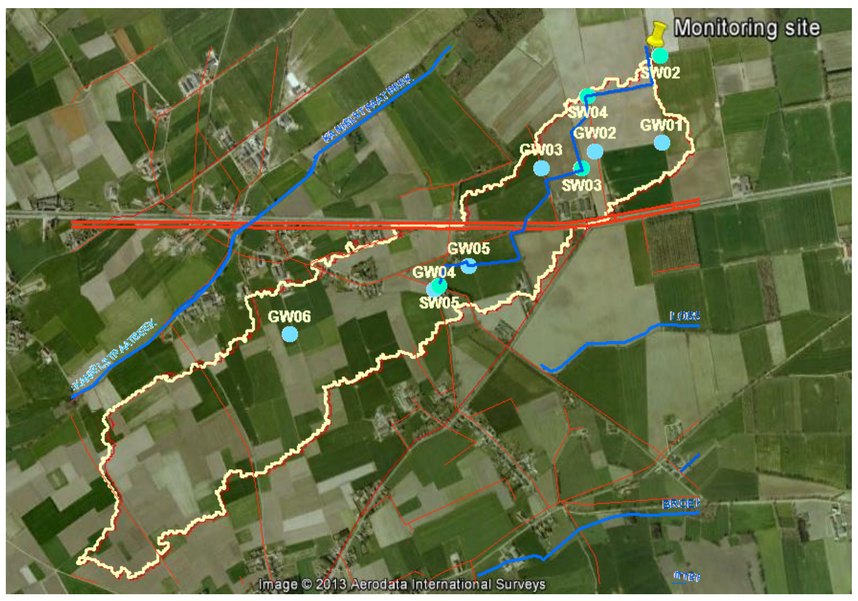
In the context of the EU Nitrate directive and supported by the Flemish Land Agency, a project on surface water quality was started in 2012 in the area of the Horstgaterbeek, a stream in North Limburg, Flanders. The area has an important agricultural activity, with many livestock farms and grassland, but also arable crops. It is a flat area with sandy to sandy-loam soils and shallow groundwater tables. In the area, a monitoring site for surface water quality, belonging to the monitoring network of the Flemish Environmental Agency and situated in a small ditch, the nitrate content regularly exceeds the standard (50 mg NO_3^-.l^{-1}). The aim of the project was to gain a better insight in the nitrate flows within the catchments of the monitoring sites and to improve surface water quality, through an intensive follow-up of the agricultural activities, in collaboration with the local farmers.



The catchment of the monitoring site was determined, covering a total area of about 140 ha (fig. 1). In this area, information was collected on:

- Water flows: drainage, streams and ditches were mapped.
- Farms: the agricultural parcels in the study area belong to cattle farms (6), pig farms (4) and 1 arable farm.
- Agricultural parcels: soil types vary from sand to sandy loam. In most of the parcels, the C-content as well as the pH are below optimum. The P-content is mostly high.
- Fertilisation history: on all the parcels considerable amounts of cattle or pig slurry are applied frequently.
- Crops: the project area consisted mainly of maize and grassland parcels, belonging to livestock farms. Also sugar beet, peas, beans, fodder beet, potatoes and spring barley were grown.

During 3 years (2012-2014), water quality as well as soil nitrogen content and agricultural activities were monitored intensively.

Fig. 1 – Location of the study area and the water quality monitoring sites (SW = surface water; GW = groundwater).

Monitoring of the nitrate residues (0-90 cm)

Nitrate residues were measured in autumn in the agricultural parcels. Both in 2013 and 2014, significant improvements were observed in comparison to 2012 (first project year).

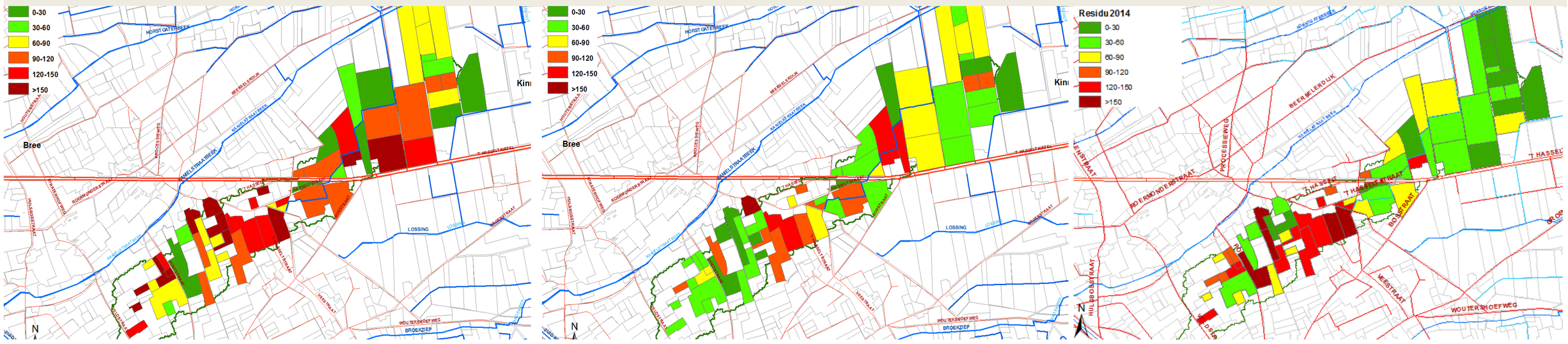


Fig. 2 – Nitrate residues (0 – 90 cm) measured in autumn in 2012 (left), 2013 (center) and 2014 (right).

Soil mineral N balance model

N input	N output
atmospheric deposition	
mineralisation from SOM, based on: - C-content - soil texture - soil temperature - **soil moisture content: calculated with soil moisture balance**	losses through: - denitrification - **leaching: calculated with soil moisture balance**
mineralisation of crop residues	uptake by crops and catch crops
fertilisation: mineral & organic	

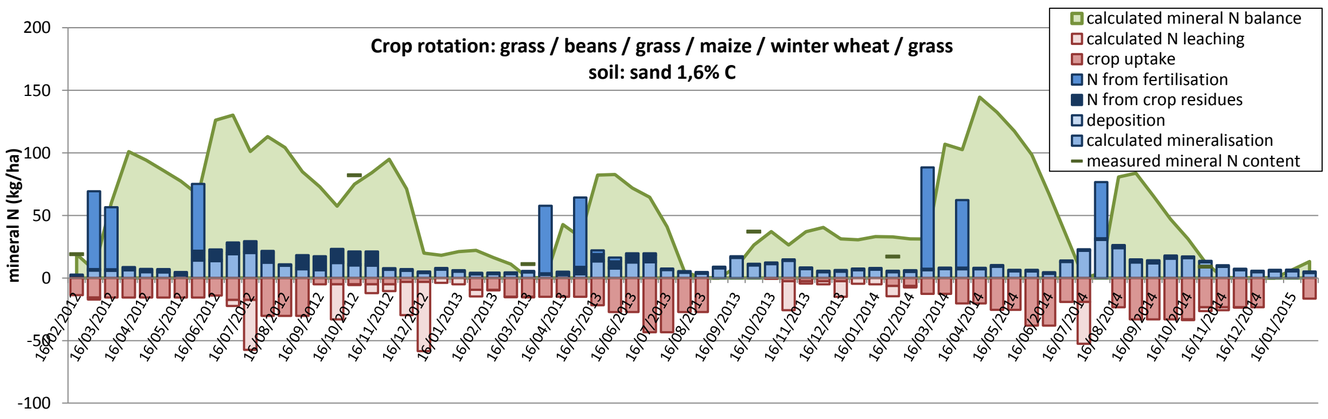


Fig. 3 – Example of the modeling of the soil mineral N balance in an arable field in the Horstgaterbeek area.

In order to gain a better insight in the N-dynamics in the agricultural parcels, a mechanistic modeling approach of the mineral-N-balance in the soil was developed. In this approach, the different in- and outputs of nitrogen are estimated. N-mineralisation from soil organic matter is calculated based on the potential mineralisation rate and taking into account soil temperature and moisture. N leaching is estimated from the calculation of the water flushing rate through the soil profile. Both the soil moisture content and the water flushing rates are calculated with a soil moisture balance model developed by the Soil Service of Belgium. This model takes into account soil characteristics, changes of the groundwater level, local precipitation and parcel specific evapotranspiration.

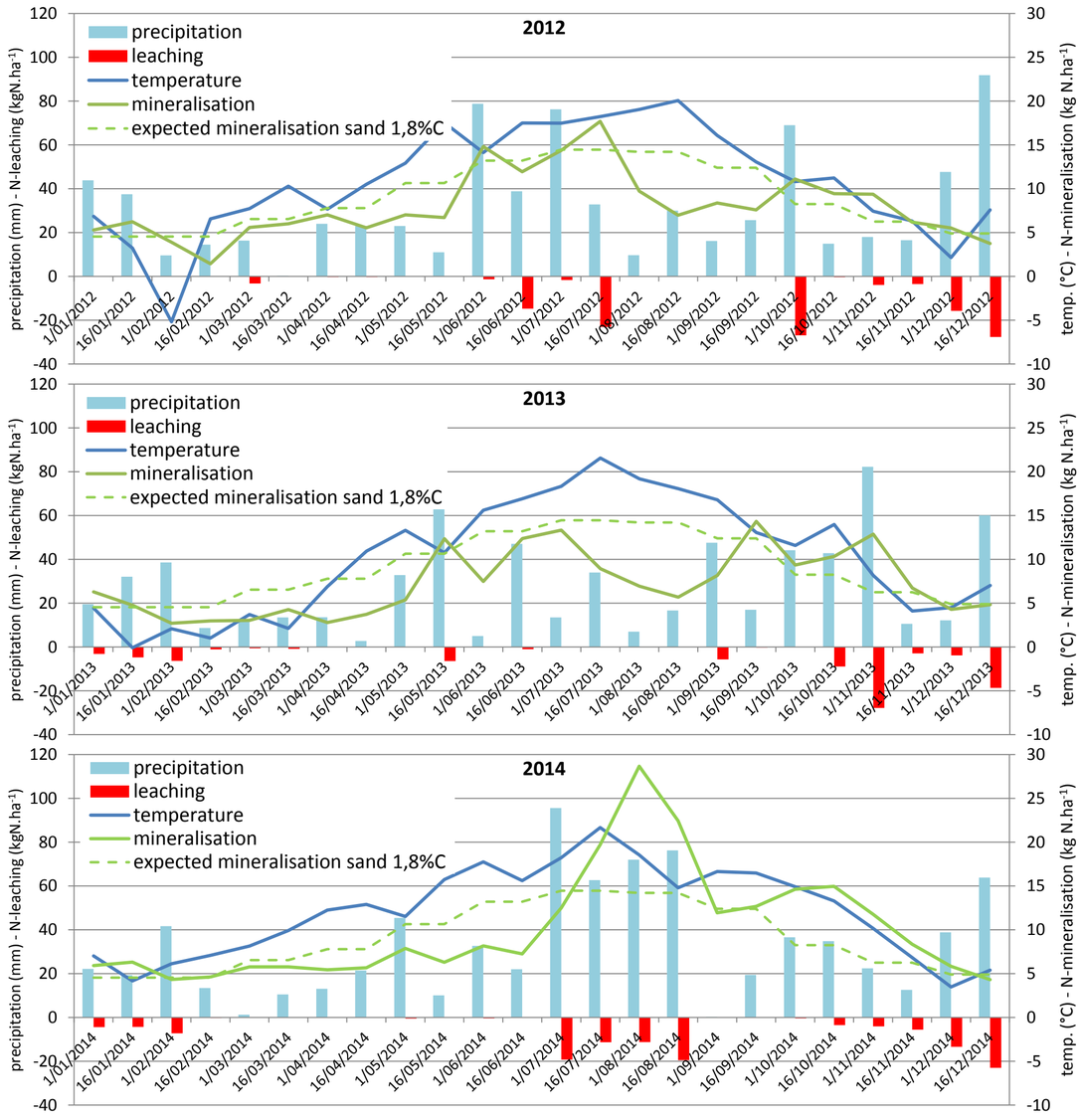


Fig. 4 – Model-based calculation of the two-weekly N-mineralisation and N-leaching: (average of 8 representative parcels) during the 3 project years and comparison with the average N mineralisation in a sandy soil with 1,8%C.

Conclusion

The modeling approach of the N-dynamics in the soil allowed us to give the concerned farmers a better understanding of the different factors (fertilisation, crop uptake, mineralisation, leaching,…) affecting the nitrate residues and nitrate losses from their agricultural parcels to the groundwater.