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How to cope best with field emissions of nitrate in a food LCA?

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Outline

- Introduction:
  - Why are field emissions important?
  - Which role plays nitrate?
- What kind of methods are available?
- Comparison of methods
- Conclusions

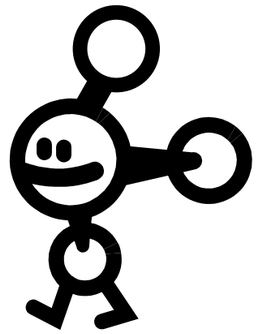
Why are field emissions important?

- Several studies showed that the agricultural phase in the production of food or biofuel plays an important role for the overall impact. (Davis and Sonesson, 2008; Zah et al. 2007)

- Examples of field emissions of nitrogen:
  - Nitrate leaching
  - Losses of ammonia
  - Nitrous oxide volatilisation

- Davis J., Sonesson U. 2008. Life cycle assessment of integrated food chains-a Swedish case study of two chicken meals. Int. J LCA 13 (7): 574-584
- Zah R. et al., 2007. Ökobilanz von Energieprodukten: Ökologische Bewertung von Biotreibstoffen. Report Empa 206 p.

Which role plays nitrate



- Nitrate emissions contribute to the nutrient enrichment in sensitive ecosystems (**eutrophication**) and the pollution of drinking water
- **Induced nitrous oxide emissions** are mostly modelled based on nitrate emissions (→ global warming).
- Nitrate emissions depend on:
  - soil characteristics (e.g. texture, field capacity)
  - climatic conditions (drainage water rate, mineralization rate)
  - agricultural management (nitrogen balance, soil tillage, cover cropping, crop rotation)

→ All these **parameters can be estimated**, but the more **precise** they should be, the more **complicated** it becomes!

What kind of methods are available?

- Fixed emission factors: e.g. Ecoinvent Report 17
- Regression models: e.g. “De Willigen”
- Empirical simulation model: e.g. “SALCA-NO3”
- Site-specific modelling: e.g. “AgriLCA”

Fixed emission factors: e.g. Ecoinvent Report 17 (Examples)

Crop	**Emission factor** % of N in fertilizer leached as NO3	**Comment**
Soy bean	30 %	General value for arable crops
Oil palm	20 %	Assumed to be lower than for arable crops
Sugar cane	2.5 %	According to model for Australia

Regression models: e.g. “De Willigen”

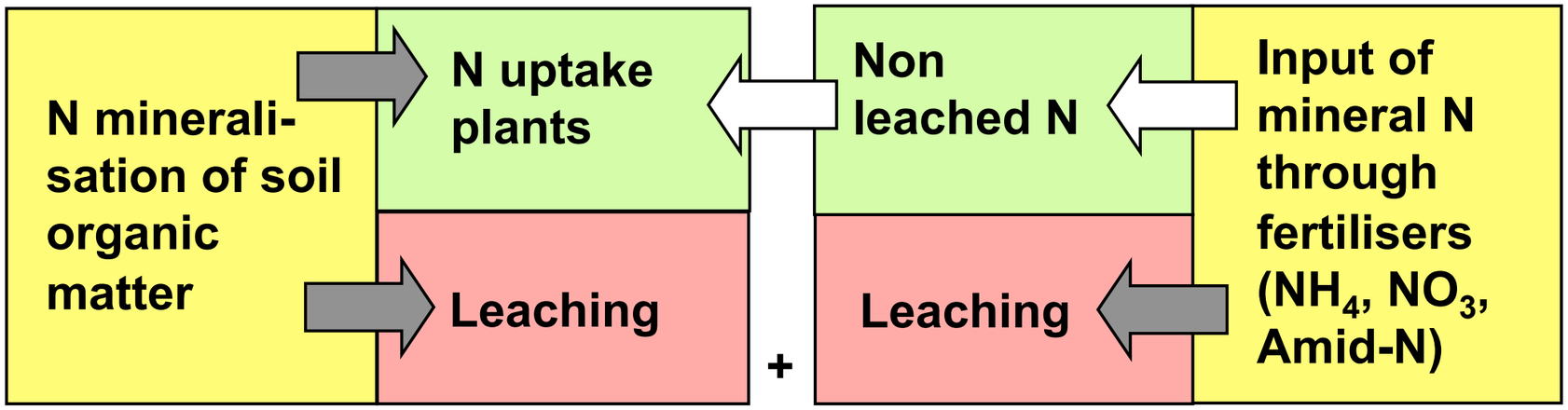
Nitrate loss through leaching [kg N kg product^{-1}]

is calculated based on:

- Annual precipitation and irrigation [mm yr-1]: P
- Clay content [%]: c
- Root depth [m]: L
- Nitrogen supply [kg N ha^{-1}]: S
- Organic carbon content [%]: C_{org}
- Nitrogen uptake [kg N ha^{-1}]: U
- Yield [tons ha^{-1}]: y

$$N = \left[21.37 + \frac{P}{c * L}\left[0.0037 * S + 0.0000601 * C_{org} - 0.00362 * U\right]\right]\frac{1}{y}\frac{1}{1000}$$

Empirical simulation model: e.g. “SALCA-NO3”



GRUDAF:
60 dt yield
158 kg N uptake

Temperature dependent

N-Uptake functions (STICS)

Example:
80 dt yield
211 kg N uptake

Monthly N-uptake

Site specific modelling: e.g. “AgriLCA”

- Basis: Simulation model SUNDIAL (SimUlation of Nitrogen Dynamics In Arable Land)
- Different rotations simulated for nine combinations of soil textures and rainfall (clay, loam and sandy soil with low, medium and high rainfall)
- Coefficients are derived for nitrate leaching for the modeled rotations.

Comparison of Methods: Scientific Soundness

Indicators	E c o i n v e n t report 17	”De Willigen”	SALCA-NO3	AgriLCA
Documentation	Report	Report	Internal report	Report
Production branches	Selected bioenergy crops	Arable crops	40 Crops, vegetables and animal husbandry	Selected crops and vegetables; animal husbandry
Management practices	Fertiliser input	Fertiliser input, yield	Crop rotation, fertiliser input, soil cultivation, yield	Crop rotation, fertiliser input, yield
Site specific parameters	None	Clay, organic nitrogen in soil, rooting depth, precipitation	Clay, organic nitrogen in soil, rooting depth, production zone (valley, hill, mountain)	Soil texture, soil organic matter, depth of soil, precipitation

Comparison of Methods: Feasibility and usefulness

Model Type	Fixed emission factors	Regression model	Empirical simulation model	Site specific modelling
Indicators	**Ecoinvent report 17 [6]**	**" De Willigen" [11]**	**SALCA-NO3**	**AgriLCA**
Data accessibility	Simple	Moderate	Detailed farming knowledge required	Detailed farming knowledge required. Simulation data needs to be generated.
Software	Not required	Web-Tool in SQCB	Excel-Tool	Simulation model
Qualification of the user	Basic	Academic	Academic	Academic, advanced
Clearness of conclusion	Limited	Limited	High	High

Conclusions

- Field emissions of nitrate are site-specific (dependent on soil, climate, agricultural management)
- Farmers' management is determining
- Limitation: experimental data is often missing
- Selection of method depends on:
  - the scope of the study
  - the availability of site-specific models for the products under investigation

Thank you for your attention!