

Notat

SEGES Innovation
Planteernæring

Erfaringer om kvælstofudvaskning fra LuWQ2025	Ansvarlig	nafb
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Erfaringer om kvælstofudvaskning fra deltagelse i LuWQ2025-konferencen

Konferencen Land Use and Water Quality (LuWQ) blev afholdt i Aarhus den 3. til 6. juni 2025. Konferencens formål er at minimere landbrugs- og arealanvendelsens påvirkning af grundvandets og overfladevandets kvalitet med fokus på den nyeste viden om systemfunktion, modellering og usikkerhed samt tværfagligt samarbejde mellem naturvidenskab, samfundsvidenskab og praksis.



Figur 1. Billede fra indgangen til LuWQ 2025 konferencen.

Hovedfokus på konferencen var overordnet:

- Næringsstofforurening (nitrat og fosfor)
- Forvaltning, regulering, lovgivning og politikker
- Naturbaserede tiltag og retentionstiltag
- Overvågning, sensorer og datadrevne tilgange
- Pesticider samt metabolitter og lignende stoffer

Formålet med deltagelsen var at indsamle den nyeste viden om kvælstofudvaskning. Dette notat omhandler nogle af de indsamlede erfaringer fra oplæg.

Indenfor området kvælstofudvaskning og relaterede emner var der især mange oplæg, abstracts og posters, som fokuserede på modellering af nitratudvaskning og -transport. På konferencen blev der præsenteret og gennemgået en række forskellige modeller, herunder modeller til vurdering af klimaeffekter på nitratudvaskning samt machine learning-modeller til at forudsige udvaskningen.

Et eksempel på et sådant oplæg er et dansk studie med modellering af ændringer i mønstre for nitratudvaskning som reaktion på ekstreme klimatiske forhold. Studiet bygger på data fra Det Nationale Overvågningsprogram for Vandmiljø og Natur (NOVANA), hvor der siden 1989 ugentligt er blevet udtaget jordvand til måling af nitratkoncentrationen fra 32 marker på tværs af Danmark. Derudover er der inddraget vejrdato, klima, jordbundstype (JB) og kvælstofbalance på marken, så den totale kvælstofudvaskning

kunne modelleres for hvert hydrologiske år, som adskiller sig fra kalenderåret, da det løber fra perioden 1. april til 31. marts i det efterfølgende år. Forståelsen af, hvordan ekstreme vejrhændelser kan øge kvælstofbelastningen til vandmiljøet, er stadig begrænset, hvorfor modellering af disse ændringer er særdeles relevant i fremtiden.



Figur 2. Billede fra session, hvor der blev fortalt om Grøn Trepert, som også var et vigtigt emne til konferencen.

Et andet område med stort fokus var måling og monitorering af kvælstofudvaskningen. Et eksempel herpå stammer fra et hollandsk studie, hvor det er blevet undersøgt, hvordan ekstreme vejrhændelser påvirker næringsstoffdynamikken i landbrugsdominerede vandløb. Studiet anvendte nationale hollandske monitoringsdata, hvor kvælstof er blevet målt siden 2012.

Resultaterne viste, at både tørke og kraftig nedbør har stor betydning for kvælstofudvaskningen. Under tørke optog afgrøderne mindre kvælstof, hvilket førte til en ophobning i jorden, og ved efterfølgende nedbørshændelser skete der en kraftig udvaskning til grundvand og overfladevand. Overvågningen viste, at kvælstofkoncentrationerne under ekstremt våde forhold kunne være op til dobbelt så høje som normalt. Studiet understreger, at klimaforandringer med hyppigere ekstreme vejrhændelser kan øge behovet for målrettede tiltag og bedre monitorering for at reducere kvælstofbelastningen.

Der var også fokus på landbrugspraksis og tiltag, der påvirker kvælstofudvaskningen, såsom efterafgrøder, præcisionsjordbrug, sædskifte, afgrødevalg, gødskningstidspunkt og -mængde samt øget brug af organisk gødning. Et belgisk studie undersøgte fleksibel timing af husdyrgødning og såning af efterafgrøder afhængigt af vejrforhold ved hjælp af en næringsstoffemissionsmodel. Resultaterne viste, at vejrforhold omkring såtidspunktet var afgørende for kvælstofoptaget, som generelt faldt ved senere såning, men med stor variation mellem afgrøder og år. Studiet viste også, at jordens vandindhold varierede mere mellem år end mellem forskellige udbringningstidspunkter, primært på grund af vejrmæssige udsving.

Slutteligt var der flere oplæg om tiltag til at reducere tab af kvælstof, før det når vandmiljøet, såsom konstruerede vådområder, bufferzoner og vådlægning af lavbundslande. Der var ligeledes fokus på

kvælstofudvaskningens betydning for grundvandet.

Et studie fra New Zealand, omhandlende et konstrueret vådområdes evne til at reducere kvælstof fra landbruget, viste, at vådområdet fjernede 55-80 % af nitraten årligt. Ved hjælp af en kombination af modeller kunne kvælstoftilførslen estimeres fra både dræn og grundvandsudsivning, som er vanskelig at måle i praksis. Resultaterne viste, at effekten var størst ved lav vandtilførsel, men den samlede fjernede mængde nitrat var højest i perioder med stor vandtilførsel, hvor belastningen toppede.

Alt i alt var konferencen meget lærerig - ikke kun i forhold til kvælstofudvaskning, men også i forståelsen af de processer, der sker, når kvælstoffet passerer rodzonen og bevæger sig videre i systemet. De præsenterede studier og diskussioner understreger, hvor kompleks problematikken er, især i fremtiden og hvordan der forsat er behov for udvikling af løsninger og viden.

Amending Water Quality through Nature-inspired Principles – an Overview

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Take-away
We have found seven measures that can improve water quality.
We expect that we can prioritize those measures by expert knowledge and literature review.
We would like to have your opinion as an expert! See bottom of the poster for more

Background
The hydrological and nutrient cycles in agricultural catchments have been impacted drastically by human intervention, causing a decline in water quality.
As climate change is only expected to increase the pressure on water quality, it is of great importance that we identify ways in which we can improve and maintain water quality for future generations.

Why nature-based?
• Often cheaper than technical equivalents
• Highly efficient at nutrient removal and retention
• Wide range of side-benefits, such as increased biodiversity and carbon capture
• Positively influence the hydrological cycle, which increases climate resilience
• Can help close nutrient cycles

Figure 1. Nutrient dynamics in the current and proposed agricultural landscape of Dutch sandy soils. Arrows convey direction and magnitude of nutrient transport, though they are not proportional. Description of numbers can be read in Table 1.

Table 1. Explanation of nutrient processes as shown in Figure 1.

Conventional	Nature-based
1. Conventional agriculture often uses considerable quantities of (artificial) fertilizer, of which only part can be taken up by crops.	Application of carbon-rich fertilizer and organic amendments stimulate soil health and slowly release nutrients over time.
2. Drainage artificially lowers the groundwater level, allowing for quick delivery of nutrients to nearby channels, with little chance for denitrification or retention of nutrients.	Removal of drainage heightens the water table. This increases water availability during dry times and enhances denitrification.
3. Low groundwater table and poor soil health reduces denitrification (returning nitrogen to the atmosphere) and nutrient retention, enhancing nutrient losses.	Denitrification is reduced due to increased denitrification and reduced nutrient losses due to increased soil health and higher groundwater tables.
4. Conventional agriculture is often associated with poor soil health due to compaction, decreased carbon stocks, loss of soil structure and reduced soil biodiversity. These factors contribute to reduced nutrient retention capacity.	By shifting to less intensive farming methods, soils become healthier: less compacted, store more carbon, have a better soil structure and a more diverse soil organism community, which contributes to soil nutrient retention capacity.
5. Due to intensive farming, soil structure deteriorates and soils become more susceptible to erosion. Soils also become more compacted and infiltration capacity decreases. Lastly, bare soils surfaces are usually left in winter. As a result, nutrient-rich sediments enter waterways via surface runoff.	By increasing soil structure and infiltration capacity due to less intensive farming practices and organic matter amendments, soil structure improves, occurrences of overland flow decrease and soils become less susceptible to erosion. Winter cover crops protect the soil against erosion in winter.
6. Narrow banks with steep inclines allow for soil erosion and have a draining effect on the bordering field.	Broad, gently sloping banks increase the riparian zone where vegetated buffer strips can filter sediment, take up nutrients and enhance denitrification.
7. Straight and narrow ditches with little vegetation cut through the landscape, efficiently transporting nutrients and sediment downstream.	Ditches are widened and vegetation is allowed to take hold. Stream morphology is adjusted to allow for sedimentation. Periodical removal of vegetation and sediments prevents saturation and closes the nutrient cycle.

Which measure do you think will be most effective?
Or do you have any other suggestions? Please let us know by writing your suggestion with your reference on a post-it or by filling in the survey in the QR code and clicking the link.

References:
1. Vries, L. (2023). Growth impacts on the water quality of freshwater systems: review and integrations. *Earth-Science Reviews*, 140, 105124. <https://doi.org/10.1016/j.earscirev.2024.105124>

Figur 3. Et par spændende posters fra konferencen om Forbedring af vandkvalitet gennem naturinspirerede principper (venstre) og Virkninger af sædskifte på nitratudvaskning på markniveau (højre).

Evaluating Agricultural Strategies for Groundwater Protection: Impact of Crop Rotations on Nitrate Leaching on Field Scale, Denmark

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INTRODUCTION
• Surface and groundwater pollution by NO₃-N is a major environmental issue on a worldwide scale.
• Agriculture contributes nitrate to the aquatic environment, groundwater, lakes, streams, and the marine environment.
• In Denmark, where 61% of the land is farmed, nitrate risk is especially high.
• Grassland rotations are promising: they have a lower nitrate leaching level than monocultures.
• Crop rotations with a high share of grassland might mitigate nitrogen (N) leaching more effectively than monocultures.

OBJECTIVES
➢ To analyze the effect of introducing a high share of grass-clover pastures in the cropping systems and measure the effects on field nitrate leaching.

METHODS AND MATERIALS
Six fields (S1-S6) with different management strategies (Table 1) were monitored during 2022-2024. At each site, soil texture was analyzed (Fig. 1). Suction cells were installed at a depth of 1 meter with eight replications (Fig. 2). Soil water samples were collected biweekly from autumn to spring and monthly during the summer.

RESULTS
➢ S1 and S2 (Grass-clover): Maintained consistently low nitrate-N levels (<5 mg/L) throughout 2022-2024 (Fig. 3), confirming strong nitrogen retention in long-term perennial systems (Li et al., 2024).
➢ S4 (Maize with undersown grass): Started with very high nitrate-N (30+ mg/L), dropped mid-2023 (Fig. 3), but increased sharply again in late 2024, reaching the highest levels of all treatments (40 mg/L).
➢ S3 (Spring barley) and S5 (Ryegrass, wheat): Showed moderate nitrate-N concentrations (5-15 mg/L) with seasonal fluctuations (Fig. 3).
➢ S6 (Wheat, grass for seed): Stable mid-range nitrate-N (10 mg/L), with modest fluctuations, but lower stability than S1 and S2 (Fig. 3).
➢ Seasonal Trends: Most treatments exhibit lower concentrations during summer, rising in autumn/winter, highlighting post-harvest leaching risk (Wey et al., 2022).

CONCLUSION
Grass-clover systems (S1, S2) consistently minimized nitrate losses, while maize systems (S4) showed the highest leaching level. Nitrate accounted for 77-89% of the total N, confirming that monitoring nitrate alone is sufficient for estimating N leaching risk, supporting its continued use as a cost-effective proxy in field and regular monitoring. Seasonal peaks highlight the need for targeted post-harvest management (e.g. cover crops).

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Li, D., Wang, J., Chen, B., Chen, J., Zeng, J., Li, L., Wei, D., & Guo, H. (2024). Review: Nitrogen application, assimilation, and seasonal cycling in perennial grasses. *Plant Science*, 342, 112854.
Wey, H., Nannipieri, P., Bruch, W. A., & Boller, T. K. (2022). Field-scale monitoring of nitrate leaching in agriculture: assessment of three methods. *Environmental Monitoring and Assessment*, 186(1).

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Table 1. Crop rotation in different fields during the study period

Fields	2022	2023	2024
S1	Spring barley undersown Grass-clover	Grass-clover	Grass-clover
S2	Spring barley undersown Grass-clover	Grass-clover	Grass-clover
S3	Spring barley	Spring barley-undersown grass	Grass-clover
S4	Grass-Clover	Maize (undersown grass)	Maize (undersown grass)
S5	Spring barley (undersown grass)	rye grass for seed	Winter Wheat
S6	winter wheat	spring barley (undersown grass)	Spring Barley

Figure 1. An example of the soil texture from S4 in two horizons A and B.

Figure 2. Overview of the six monitored fields (S1-S6) located near Skive, Denmark, representing different cropping systems. The photos show site layout, installation of 8 suction cells at 1 m depth per site/field, and the water sampling.

Figure 3. Nitrate-N concentrations (mg/L) measured in drainage water from six cropping systems (S1-S6) over two years.

Figure 4. Comparison of total nitrogen and nitrate-N concentrations for each cropping system (S1-S6).