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Hydrology of a Danish Riparian Lowland:
The Importance of Groundwater Upwelling on Nitrate Removal

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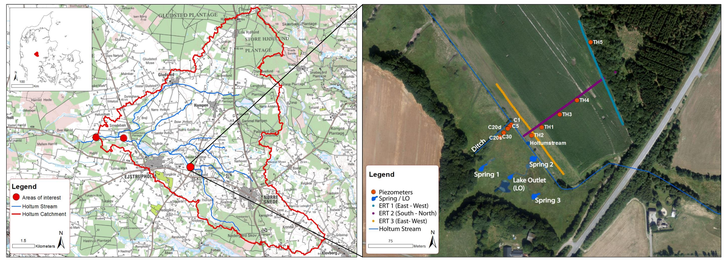
Introduction

Riparian lowlands are critical interfaces between streams and uplands with many of the characteristics for being critical areas for nitrate removal. Their hydrogeology controls flow paths, magnitude of groundwater discharge to the stream, nitrate loading, and therefore the occurrence of "hot spots" with increased denitrification.

Research Area

- Holtum Catchment in the central part of Jutland, Denmark. Holtum stream drains forest and agricultural areas.
- The riparian lowland and stream is located in a valley of an quaternary subglacial stream trench consisting of sandy deposits bordered by clayey tills
- The southwestern side of the stream a wetland with several springs. It is used as a cow pasture .
- The northeastern side of the stream holds a 35 meter wide buffer strip of grass and an agricultural corn field extending to the northern valley shoulder.



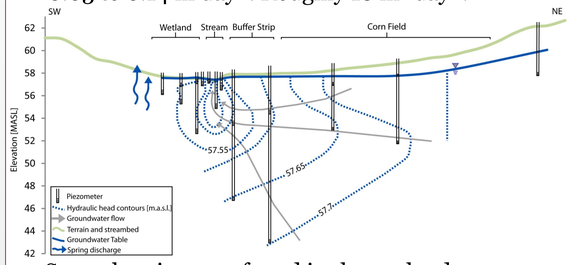
Objectives & Methods

The objective is to understand the role of the landscape and the hydrology on diffusive vs. focused groundwater discharge and the effect on nitrate removal. The riparian lowland was investigated through field studies (geophysics, hydrogeology) and water quality assessment.

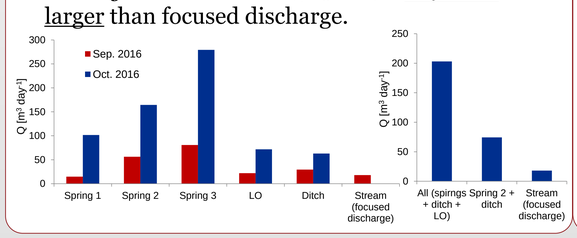
- A transect with 16 piezometers perpendicular to the stream
- 3 electrical resistivity tomography profiles (ERT)
- Water samples from piezometers, drain, stream and springs.
- Discharge from the ditch, lake outlet (LO) and springs were measured using a Baski Cutthroat Flume.
- Vertical groundwater fluxes were quantified based on vertical streambed temperature profiles.

Hydro(geo)logy

- The riparian zone is characterized by diffusive groundwater flow with direct discharge to the stream from the northern bank.
- Diffusive groundwater discharge to the stream was measured along a 100 meter section of the stream at the field site . Measured fluxes ranged from 0.03 to 0.14 m day^{-1}. Roughly 18 m^3 day^{-1}.

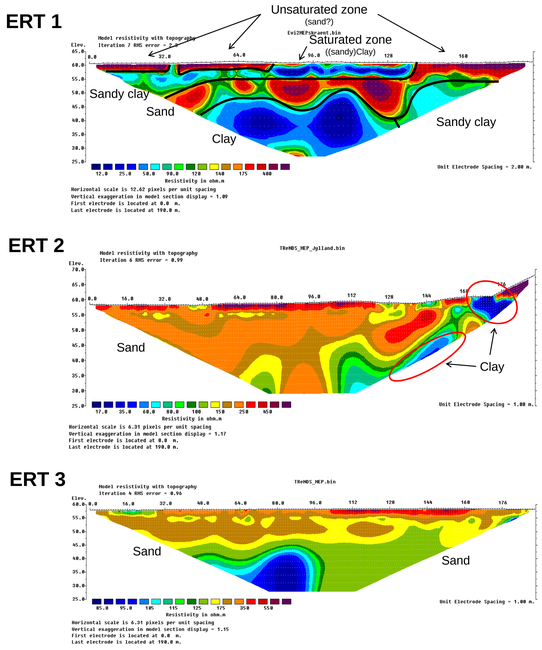


- Several springs are found in the wetland area on the southern bank, with overland flow to the stream from south. Discharge measured ranges from 15 to 81 m^3 day^{-1} and 72 to 280 m^3 day^{-1} in Sep. and Oct. 2016 respectively.
- Overland flow from the wetland discharging *directly into the stream* (spring 2+ditch) is <u>> 4 times larger</u> than focused discharge.



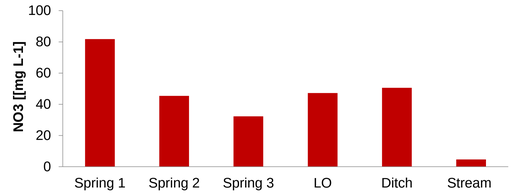
ERT

- ERT profiles 1 and 2 show sand between 5 to 10 m.b.g.l.
- The geology under the corn field is interpreted as being mainly sand. from the ERT profiles 2 and 3 – supported by measured hydraulic conductivities and well-logs in the riparian lowland.

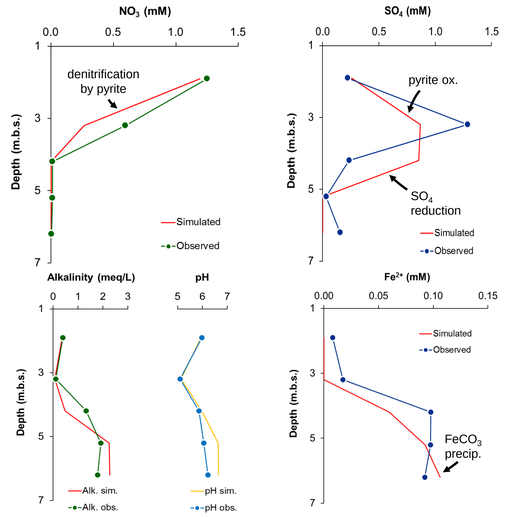


Water quality

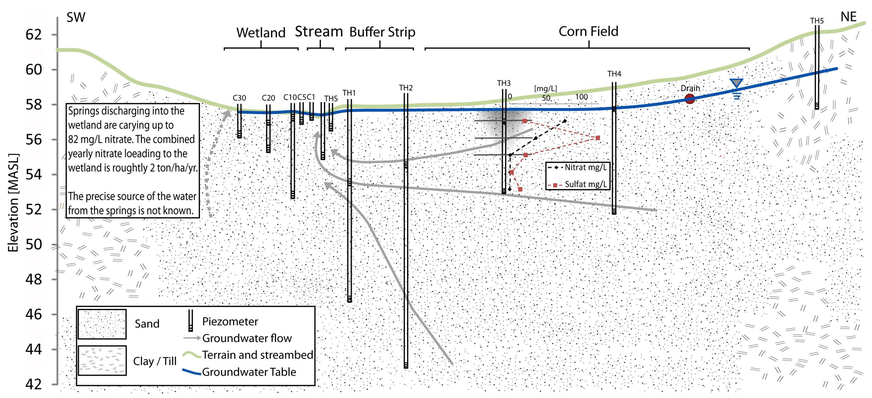
- Samples from groundwater-fed springs in the wetland, have up to 81 mg L^{-1} nitrate.



- Nitrate found in one (TH3) of the 16 sampled piezometers was modelled with a simple 1D PHREEQC model. Nitrate is removed mainly by pyrite as an electron donor from 2-4 m.b.g.l.



Conceptual Model



Summary

The riparian lowland is characterized by diffusive groundwater flow through a sandy aquifer to the stream from the northern bank. Nitrate is effectively removed by pyrite oxidation (as shown by the simple 1D chemical model and high sulphate concentrations) on the northern side.

Upwelling in the wetland represents a considerable influx from deeper groundwater or from undetected anthropogenic or natural geological subsurface drainage. Springs allow nitrate to bypass riparian denitrification making the lowland only partly effective in removing nitrate.

Results from two other riparian zones along the stream have subsequently indicated that, also on the catchment scale, the occurrence of diffusive and focused discharge control nitrate removal in these riparian zones.