

# The impacts of microbial processes and hydrogeological parameters on chemical gradients in porous groundwater systems

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# Outline

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## **Introduction**

- Groundwater
- Isotope fractionation
- Environmental isotopes and “water age dating”

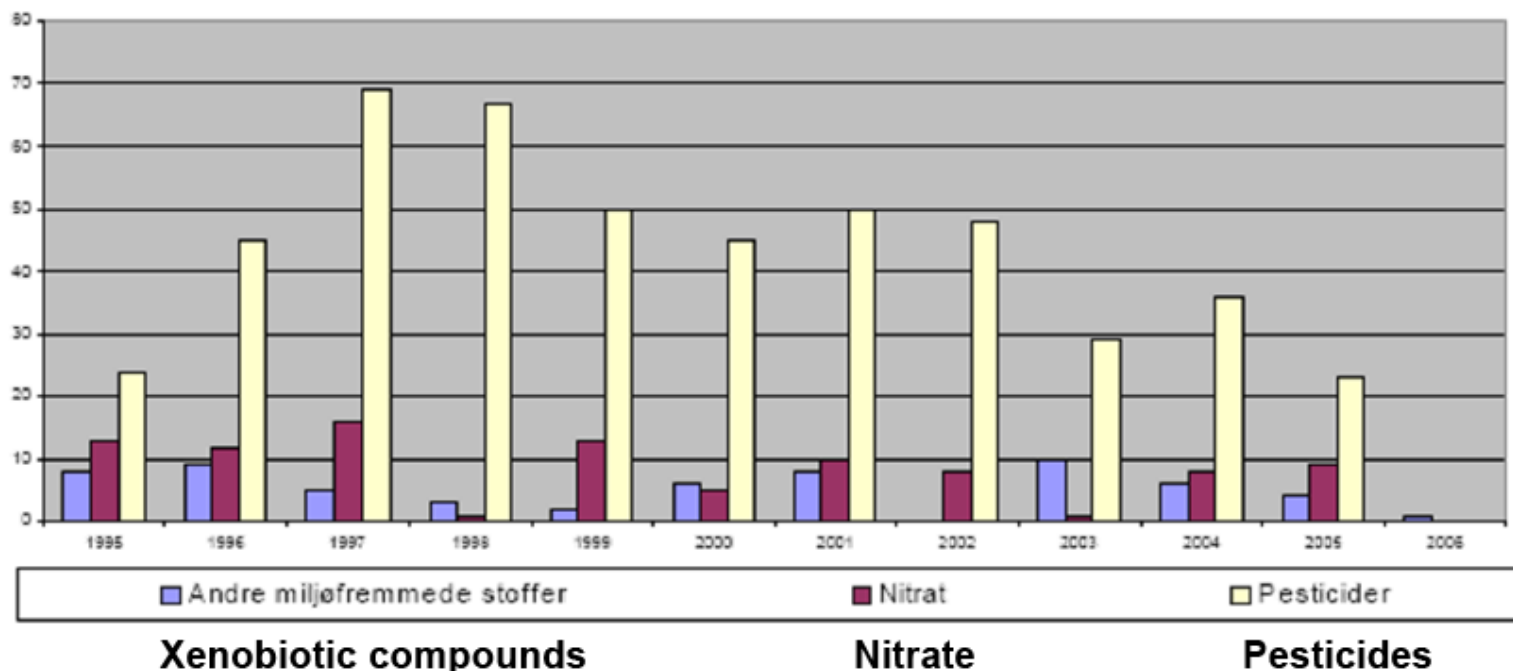
## **Results and interpretation**

# Denmark



## Closed drinking water wells in Denmark 1995-2006

Danish EPA 2006



Depotrådet: Redegørelse for Jordforurening 2006

# Remarks

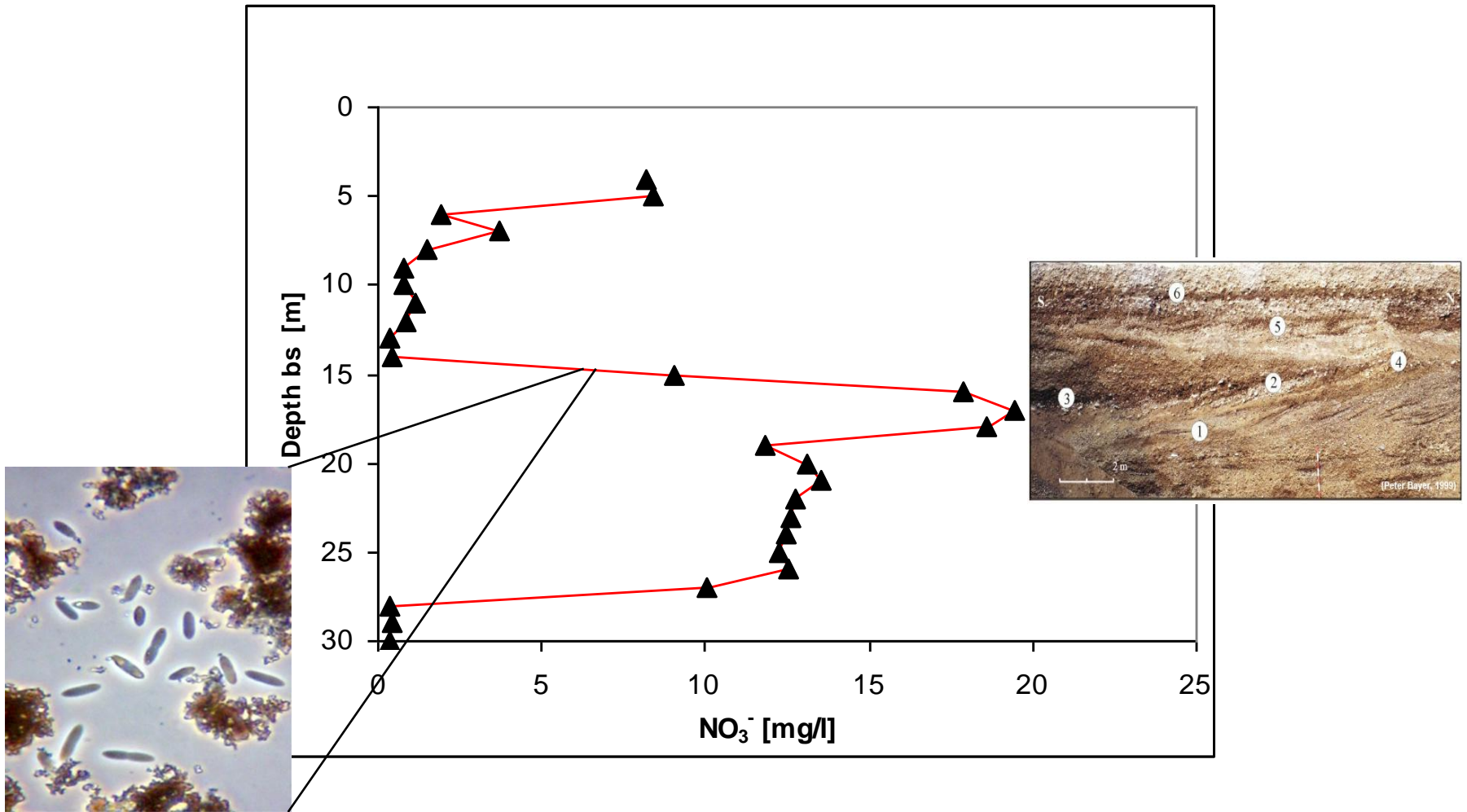
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- We have already recognised the increased human-caused pollution of groundwater ecosystems and their vulnerability.
- Microbial degradation is considered the only effective parameter for self-purification.
- However its control is still poorly understood.

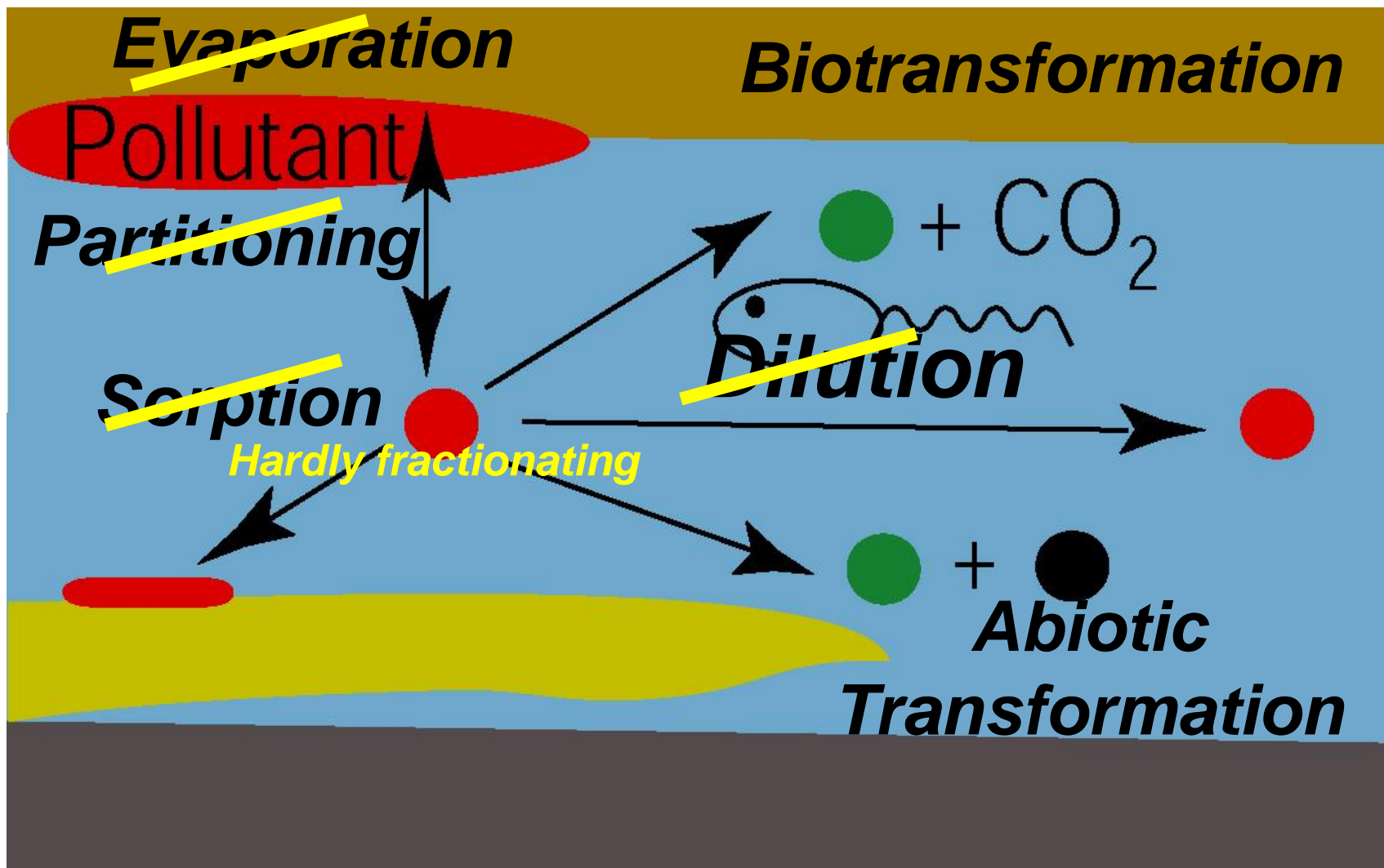
# Chemical Gradients in Marine Environments



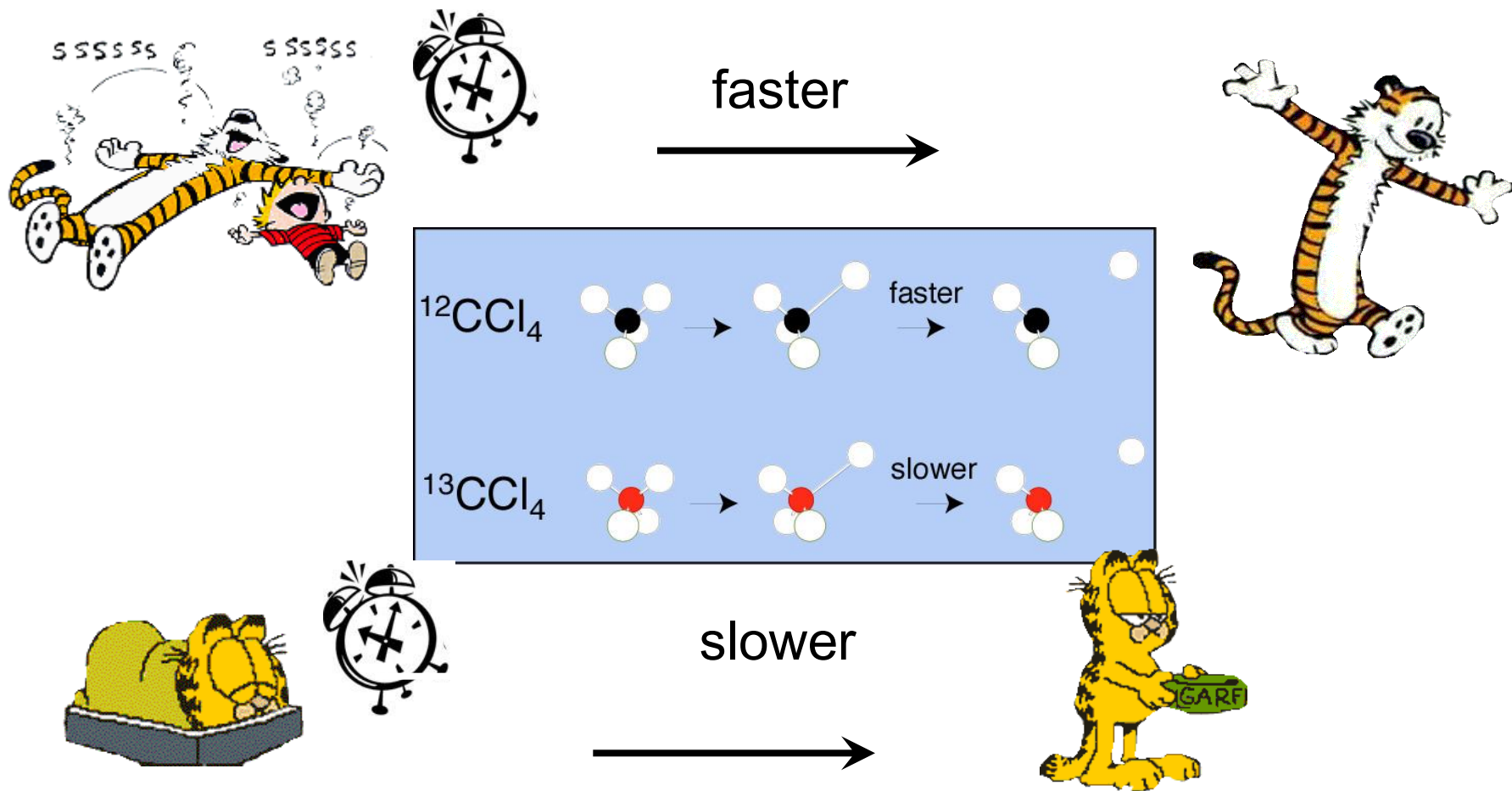
# Chemical Gradients in Groundwater



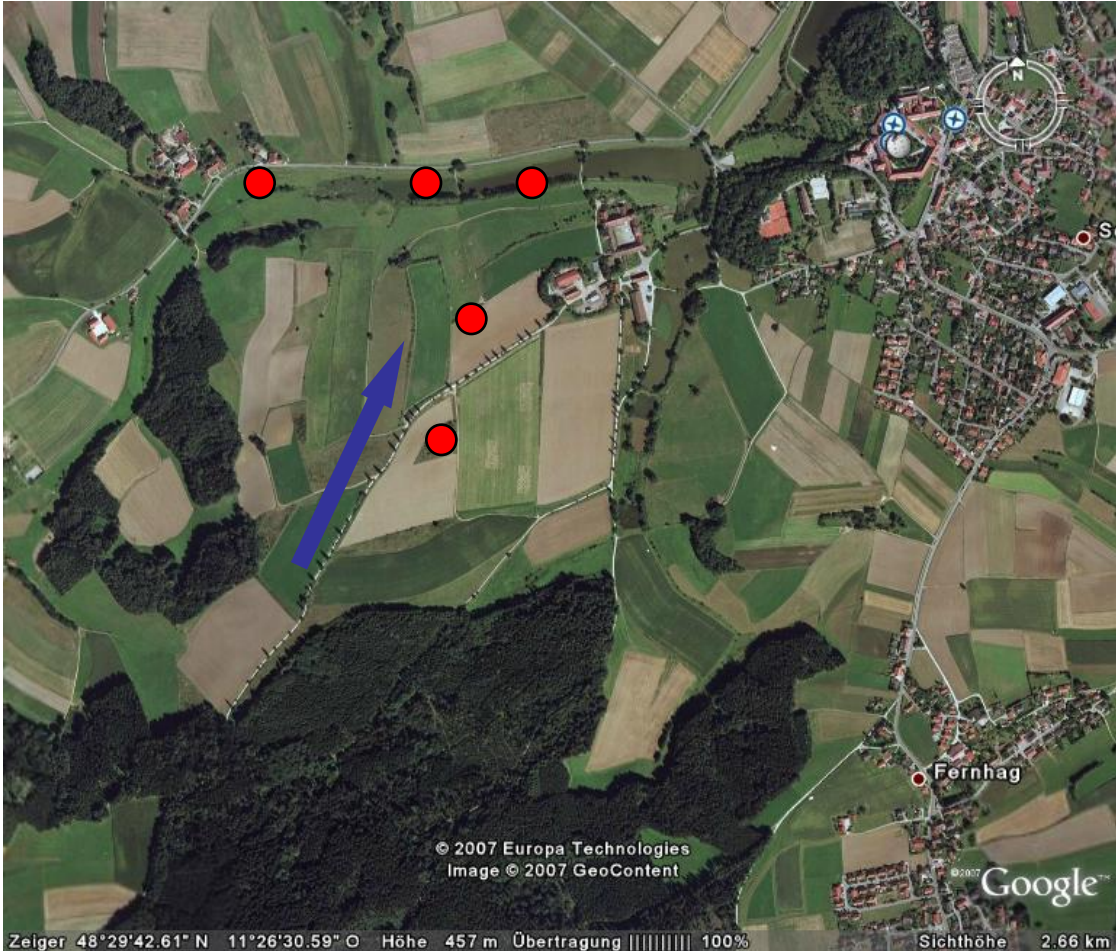
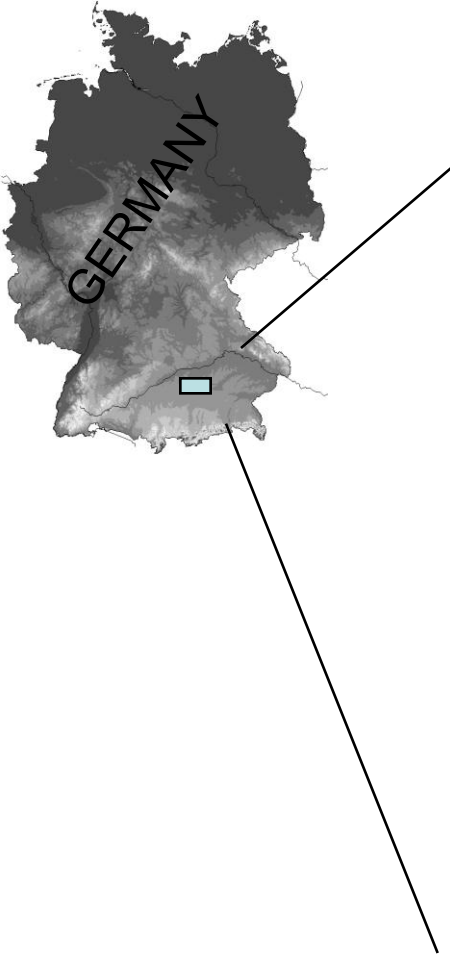
# Isotope Fractionation in Contaminant Hydrology



# The Kinetic Isotope Effect

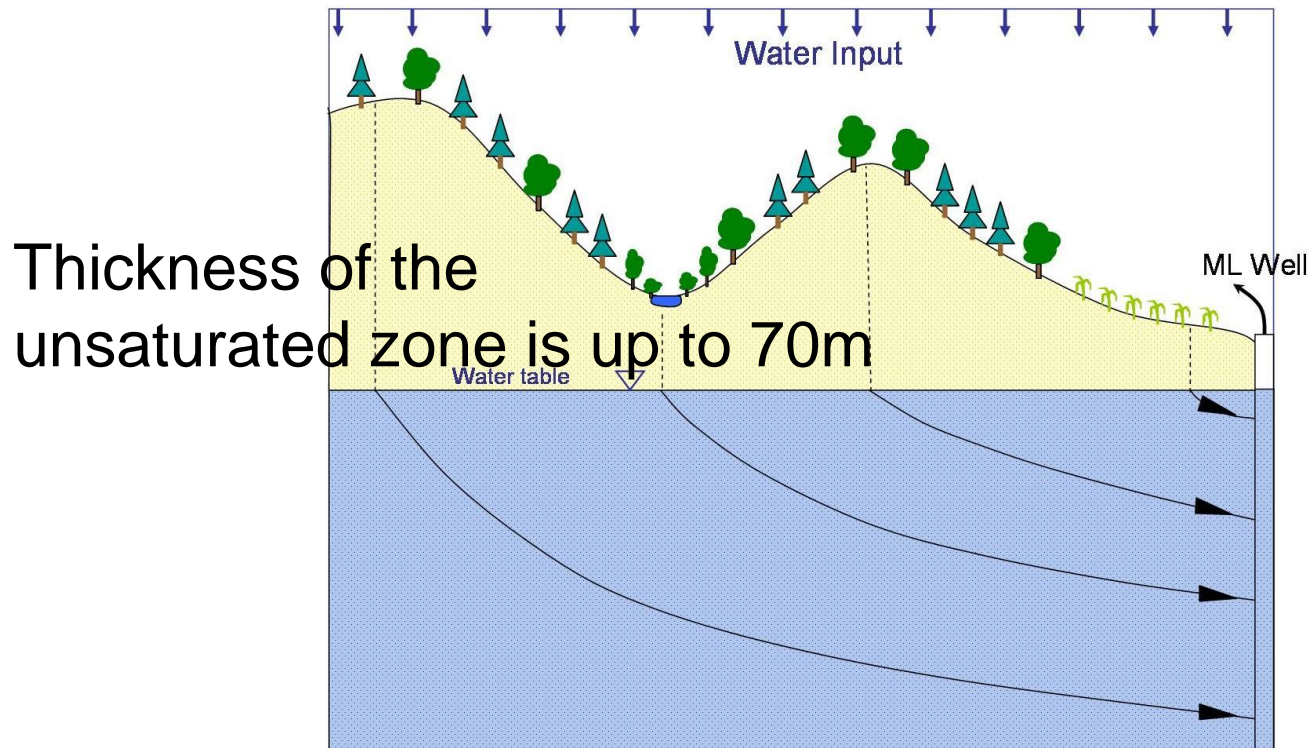


# Test Field

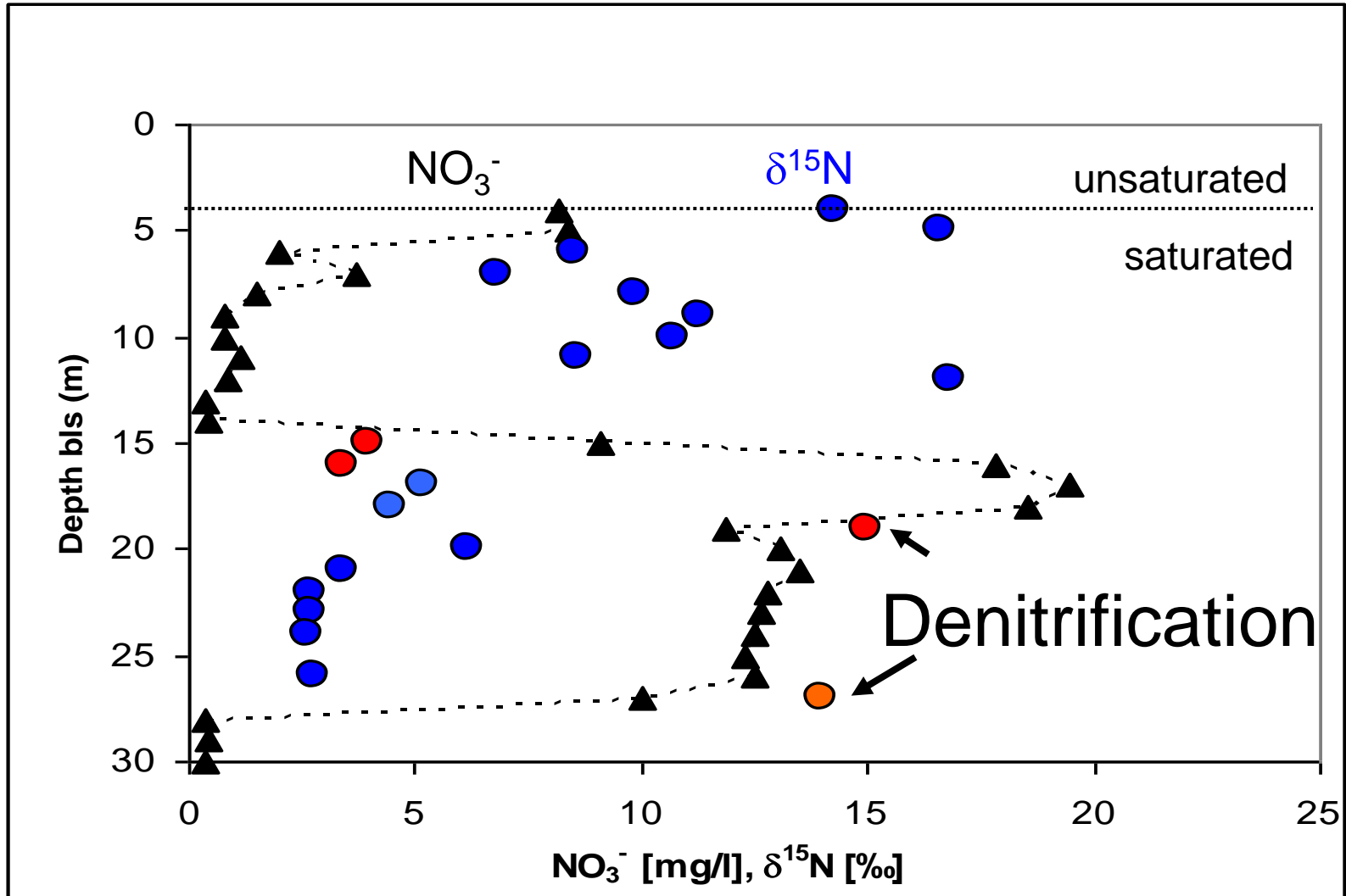


# Schematic View through the Porous Aquifer

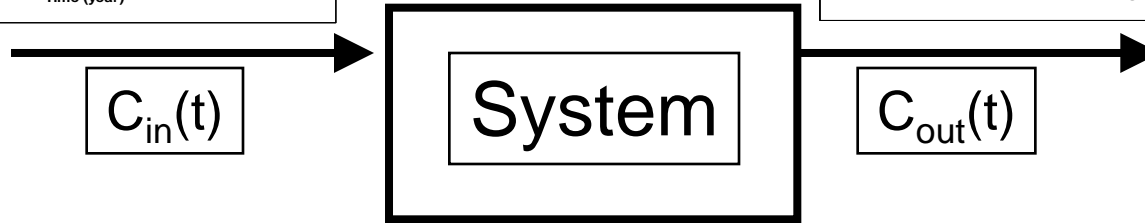
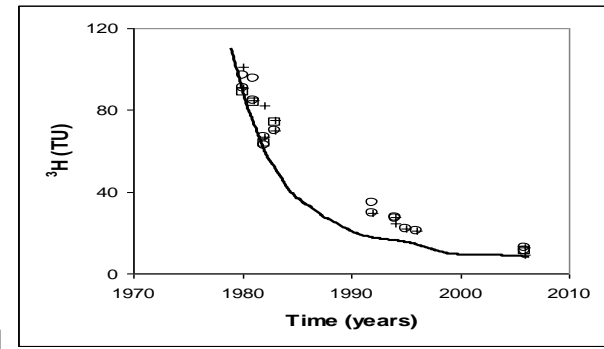
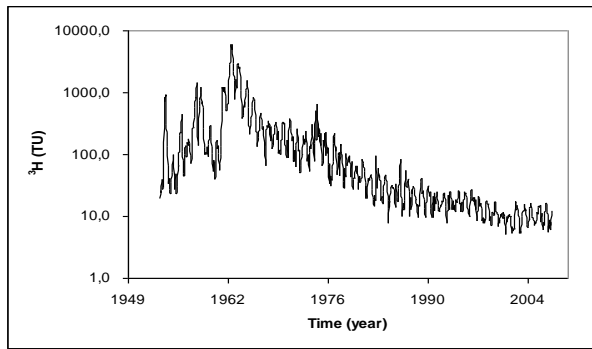
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# Depth Profile



# Water Age Dating by $^3\text{H}$



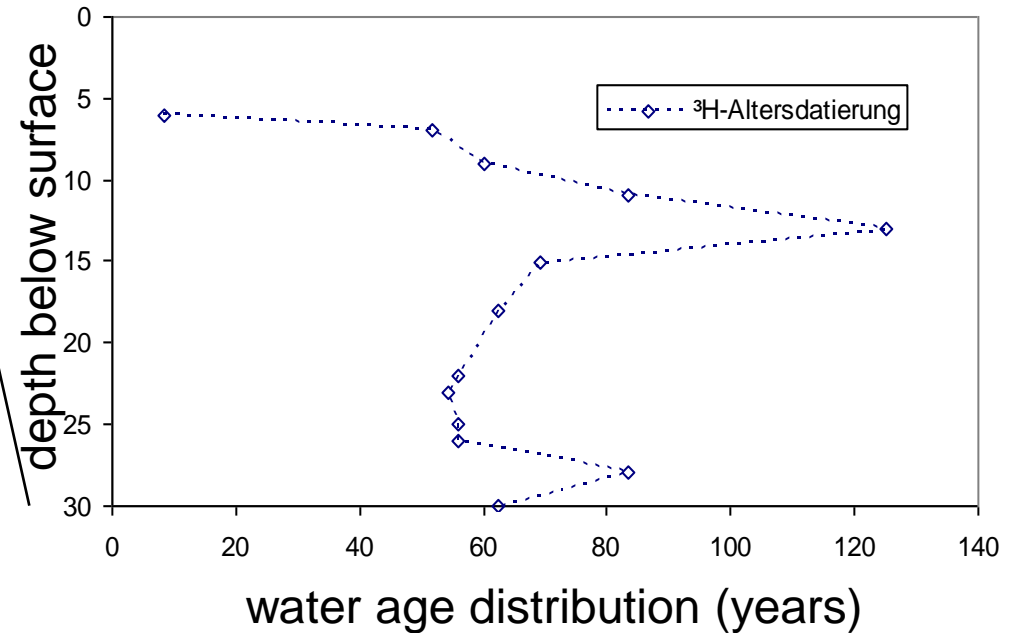
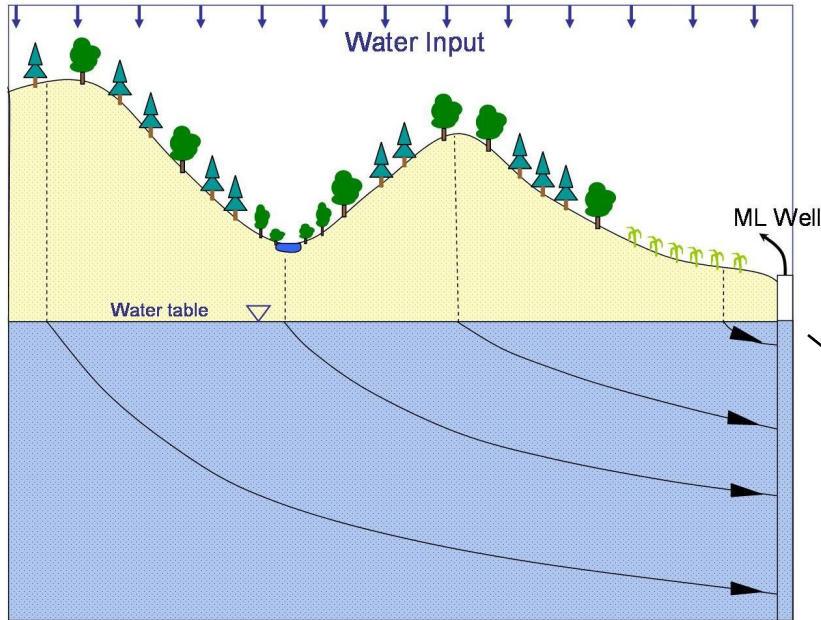
**Black-Box-application:**

$$C_{out}(t) = \int_0^t C_{in}(t-\tau) g(\tau) \exp[-\lambda(\tau)] d\tau$$

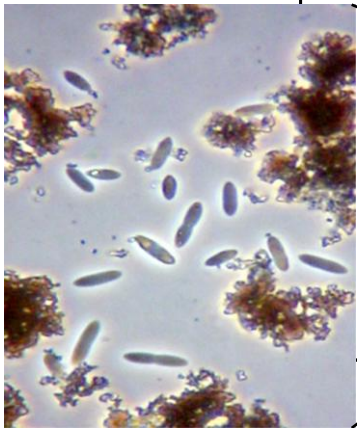
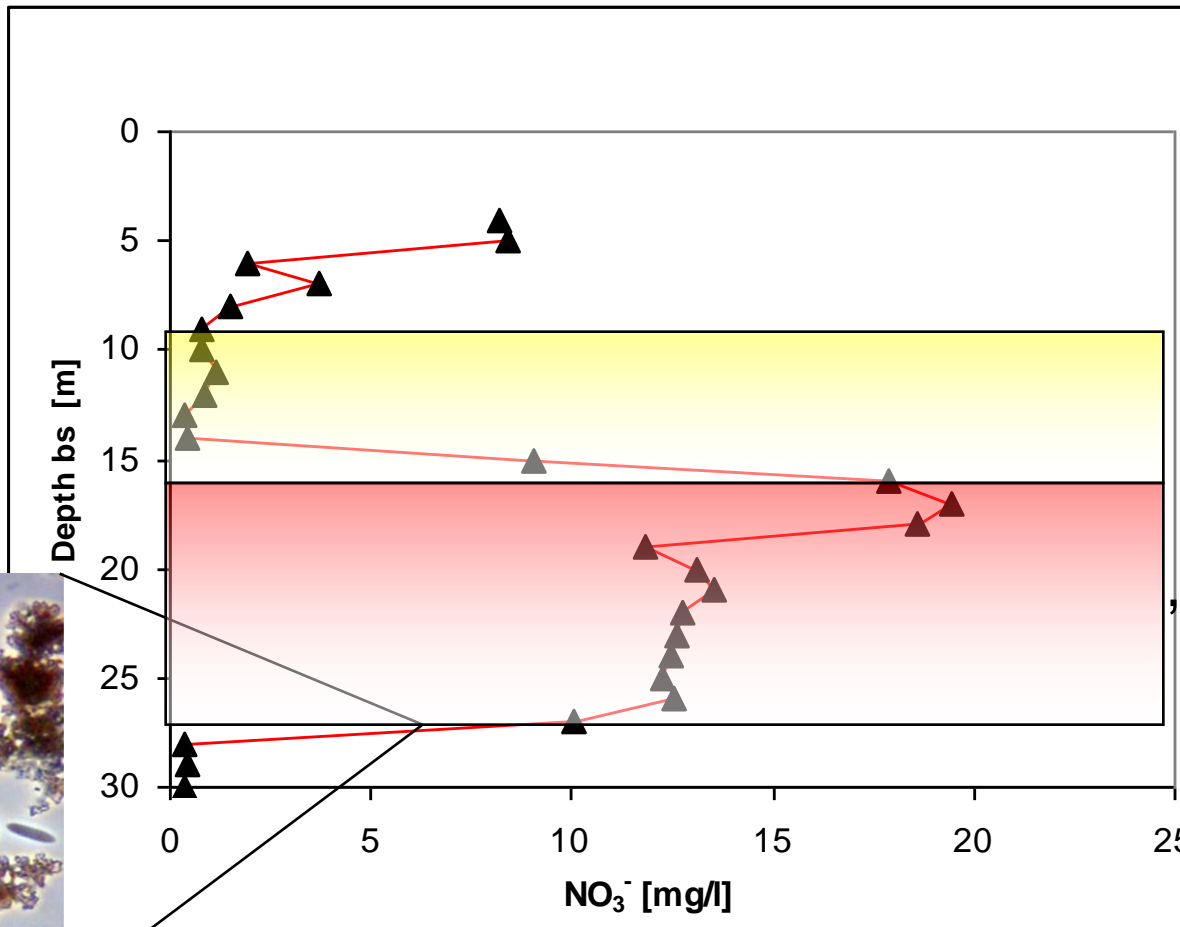
Dispersion model:

$$g(\tau) = \frac{1}{\tau * \sqrt{(4\pi P_D \tau / T)}} * \exp\left[-\frac{(1-\tau/T)^2}{(4P_D \tau / T)}\right]$$

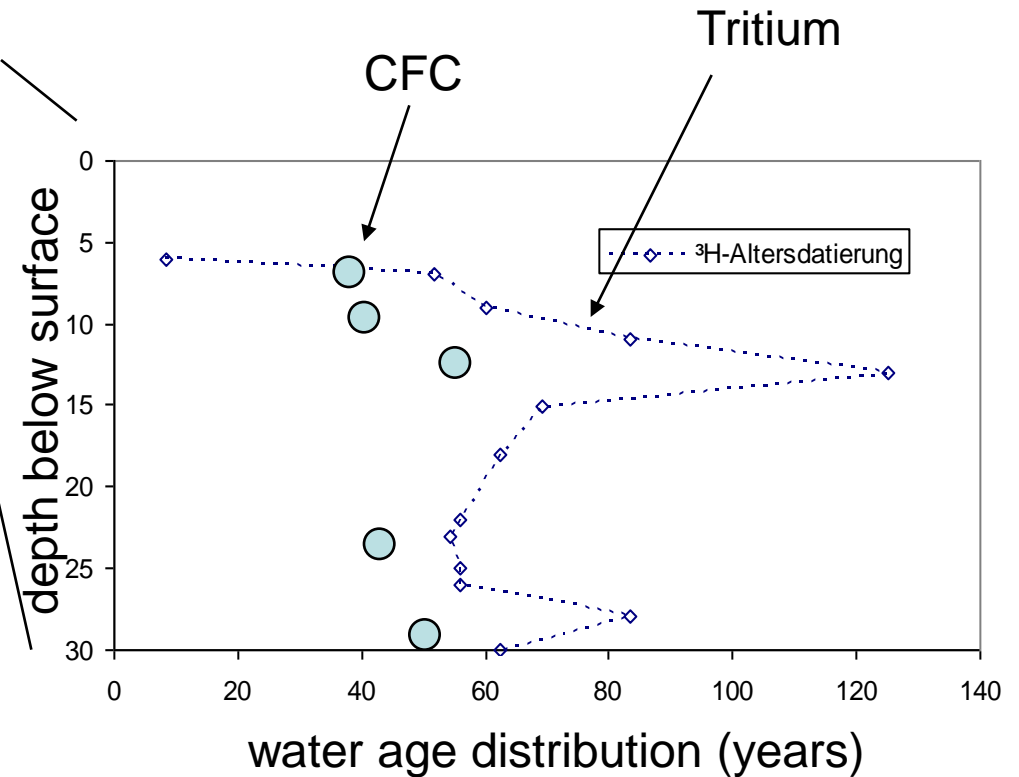
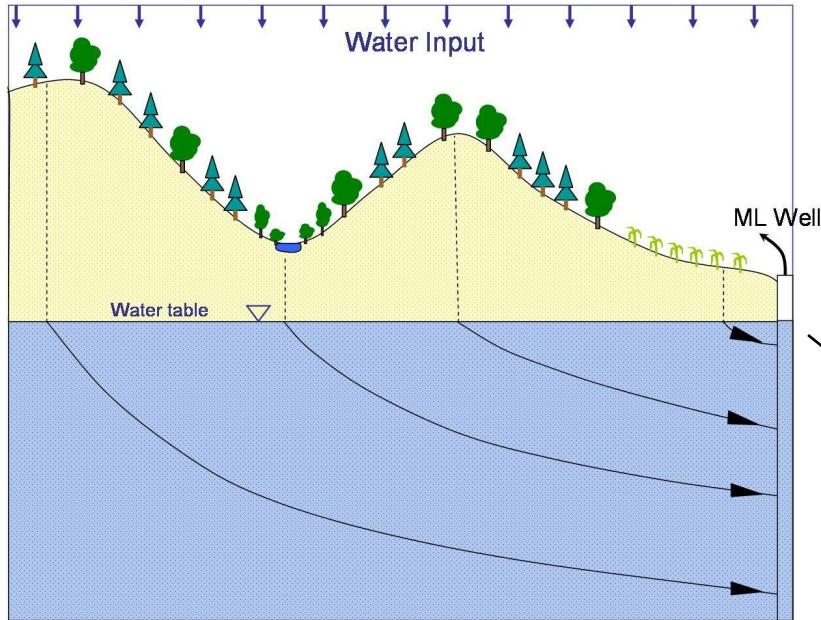
# Modeling Results by $^3\text{H}$



# Mixing Processes



# Modeling Results by $^3\text{H}$ and CFC



# Conclusion

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- Chemical gradients are formed by microbial reactions and hydrodynamic processes.
- The calculated transit time distribution in the aquifer is controlled by the thickness of the unsaturated zone.
- It is important to understand the age distribution of the system to interpret microbial processes.
- Results are incorrectly interpreted without a thorough understanding of hydrogeological conditions.

# Acknowledgement

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- Marc Schwientek
- Helmholtz Center Munich