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Improving understanding of nitrate sources in connected river and groundwater systems through linking nitrate isotopes and contaminants of emerging concern

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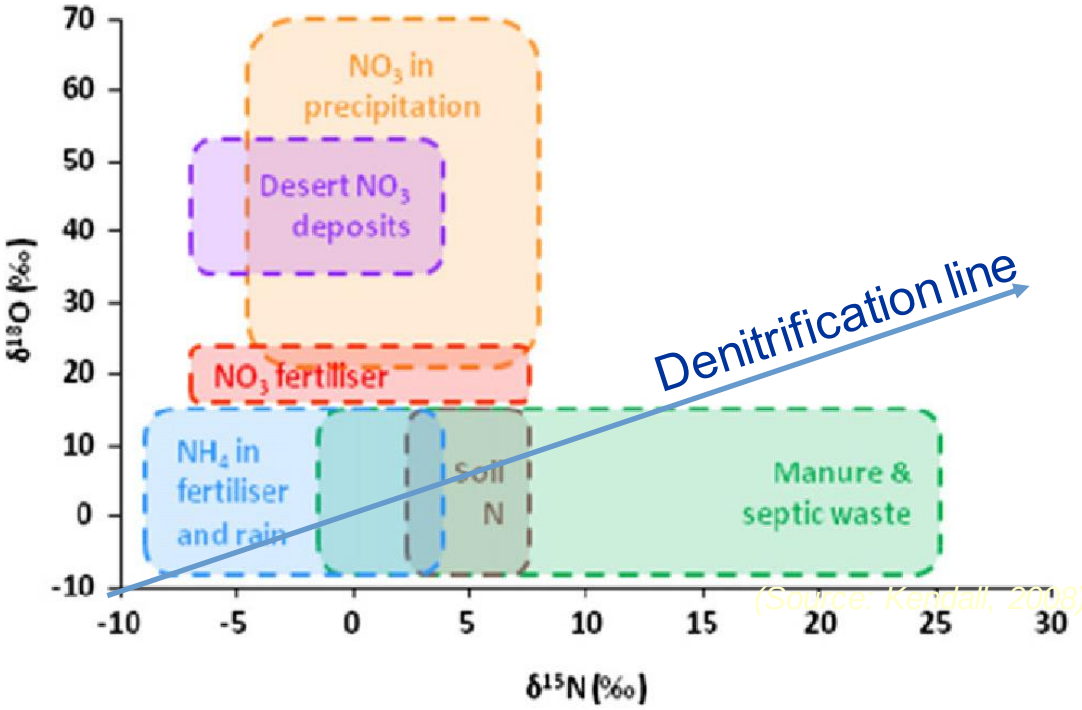
Isotope Applications

Stable isotopes are non-radioactive and non-disruptive TRACERS & INTEGRATORS

Isotopes = Nuclides of single element having different atomic weights (Soddy 1914)

Element	Isotope	Abundance
Hydrogen	^{1}H	99.985
	^{2}H	0.015
Carbon	^{12}C	98.89
	^{13}C	1.11
Nitrogen	^{14}N	99.63
	^{15}N	0.37
Oxygen	^{16}O	99.759
	^{17}O	0.037
	^{18}O	0.204

Stable nitrate (NO_3) isotopes



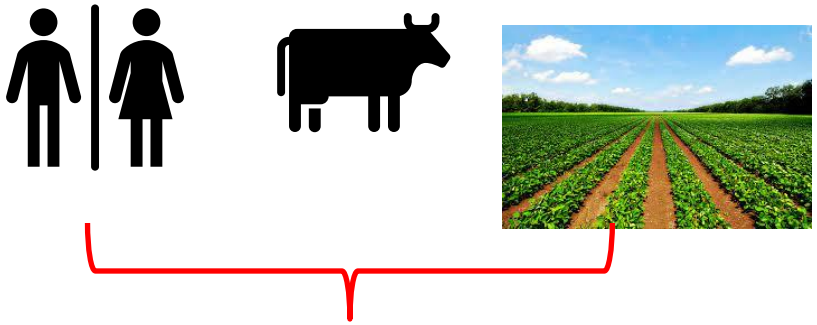
(Source: Kendall, 2008)

1. Nitrogen source identification
2. Identification of flow paths and interactions between water bodies
3. Identification of biogeochemical processes that alter nitrogen compounds and other chemical substances in water
4. Assess capacity for self remediation by denitrification

Compounds of emerging concern

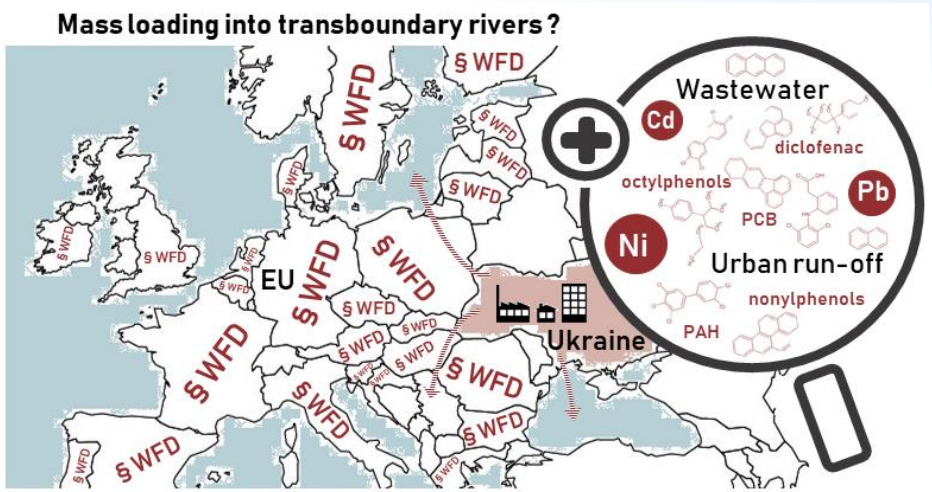
* CECs (pharmaceuticals, sweeteners, flame retardants, etc) have been detected in water bodies, they may cause ecological or human health impacts, and typically are not regulated under current environmental laws

Exact sources and pathways



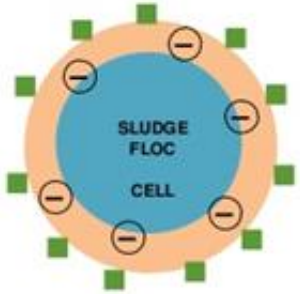
Surface/groundwater

Participation in hydrological cycle

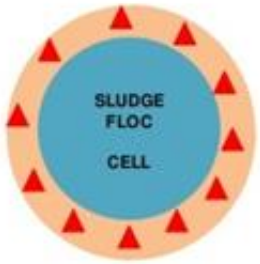


Vystavna et al. 2018 STOTEN

Behavior and factors controlling it



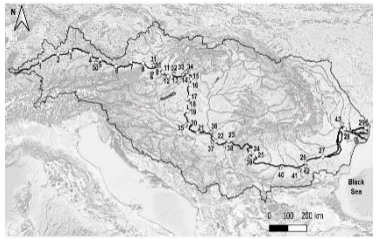
Adsorption - desorption



Absorption

Uptake by plants and degrade by microbes? Adsorption/desorption? Absorption?

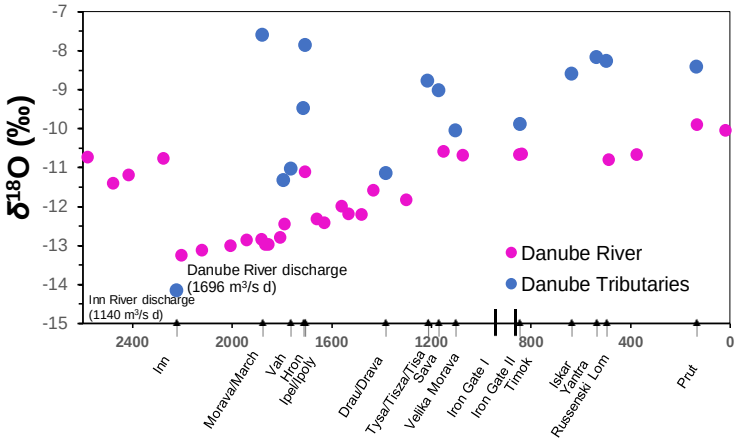
CECs + isotopes in Danube traced reduce biological activity and snowmelt controls on nitrate derived with groundwater



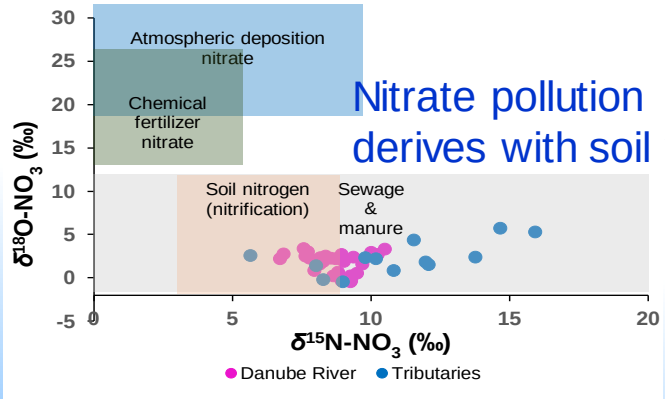
- Mixing of pollution sources
- Slower integrated responses in large rivers

CECs:

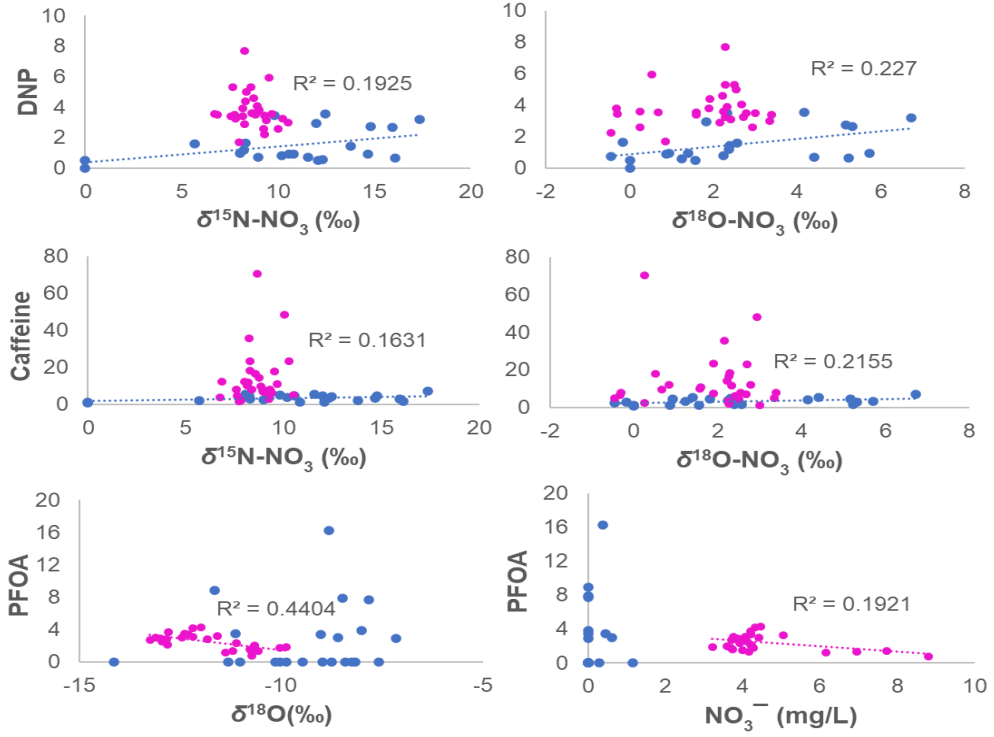
- improved hydrological processes interpretation (water transit time)
- supported tracing of nitrate sources and biogeochemical processes



Snowmelt impacts up to 1000 km



Nitrate pollution derives with soil water



Halder et al. 2022 Scientific Reports

CECs + isotopes in Ukraine traced shallow groundwater contamination and recharge by sewage and water supply systems

Kharkiv city – people prefer spring water than centralized systems

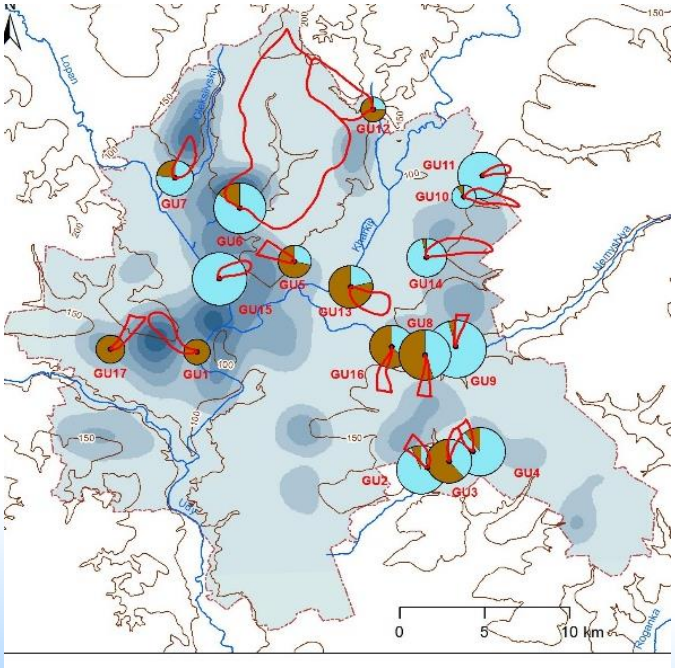
A combination of tracers:

Stable water and nitrate isotopes

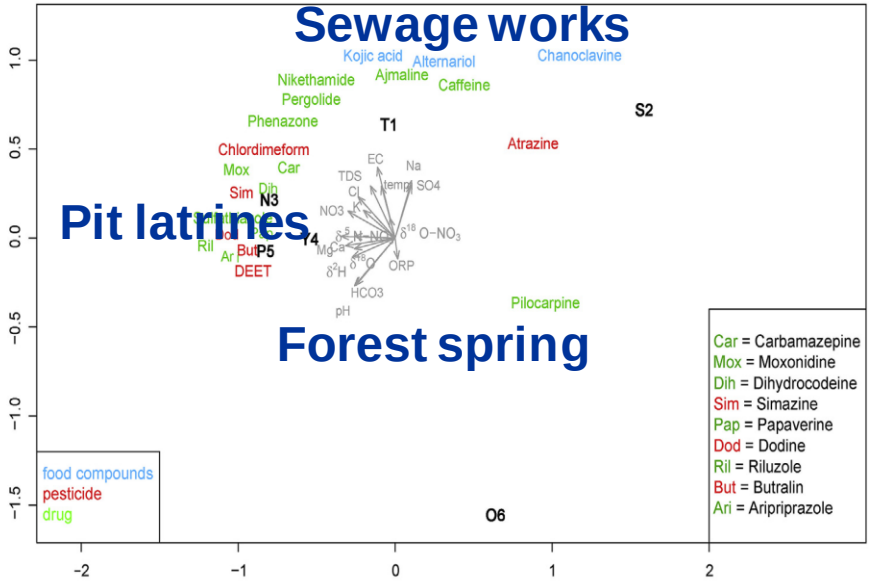
Contaminants of emerging concerns :

- describe groundwater recharge
- water origin
- water age
- trace nitrate sources
- pathways of sewage to groundwater

Urban aquifer recharges by tap water and sewage leakages (based on **stable water isotopes)**



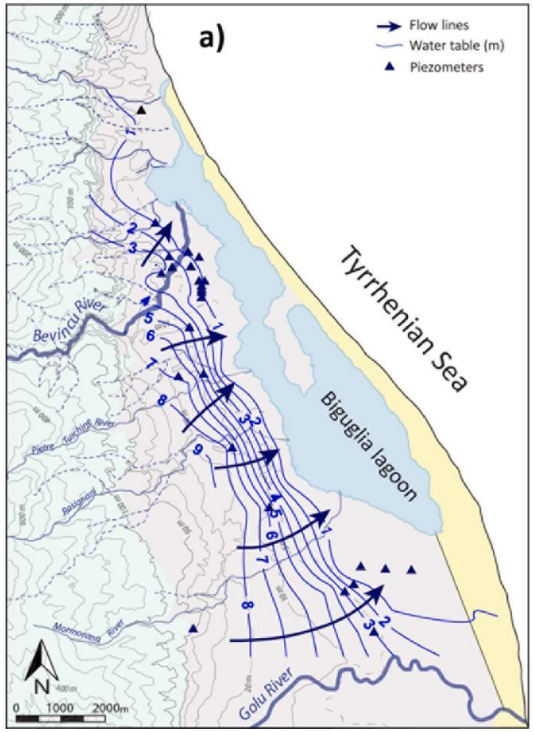
Vystavna et al. 2018 Env Earth Science

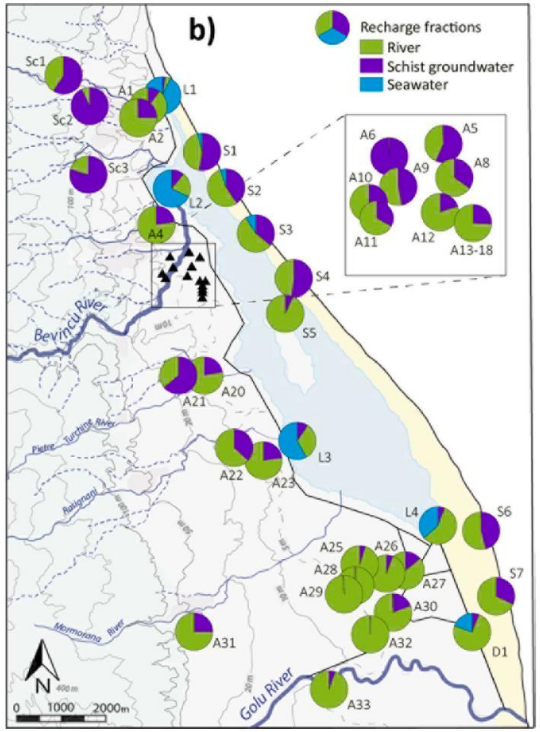


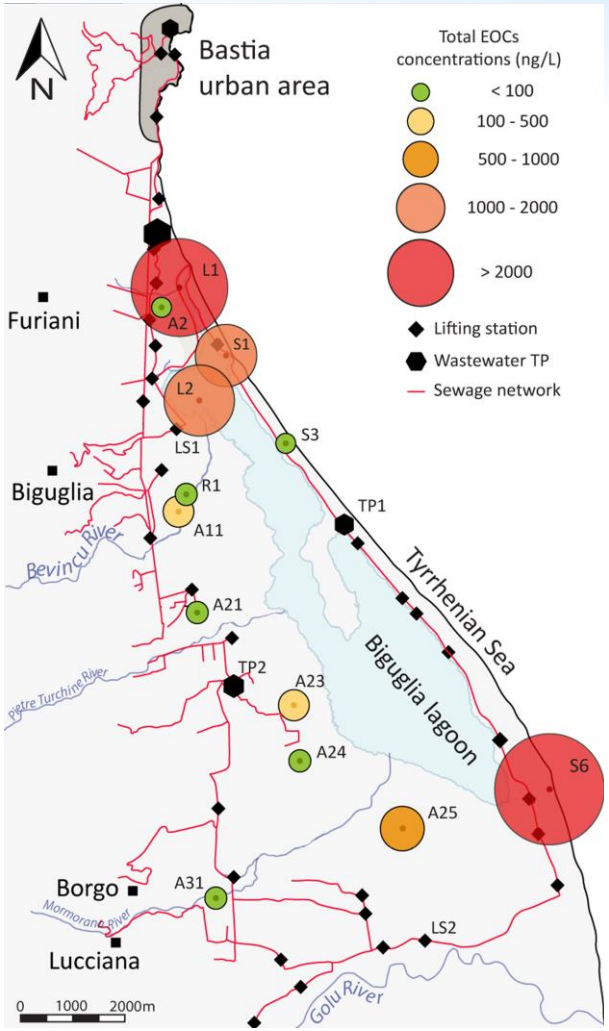
Vystavna et al. 2019 Water Research

CECs + isotopes in Mediterranean aquifer identified saline water Intrusion and groundwater pollution

Stable and radioactive water isotopes (18O, 2H, 3H) together with emerging organic compounds (EOCs) improved the understanding of strongly urbanized coastal aquifers in Corsica







Aquifers impacted by seawater intrusion had highest contamination by CECs

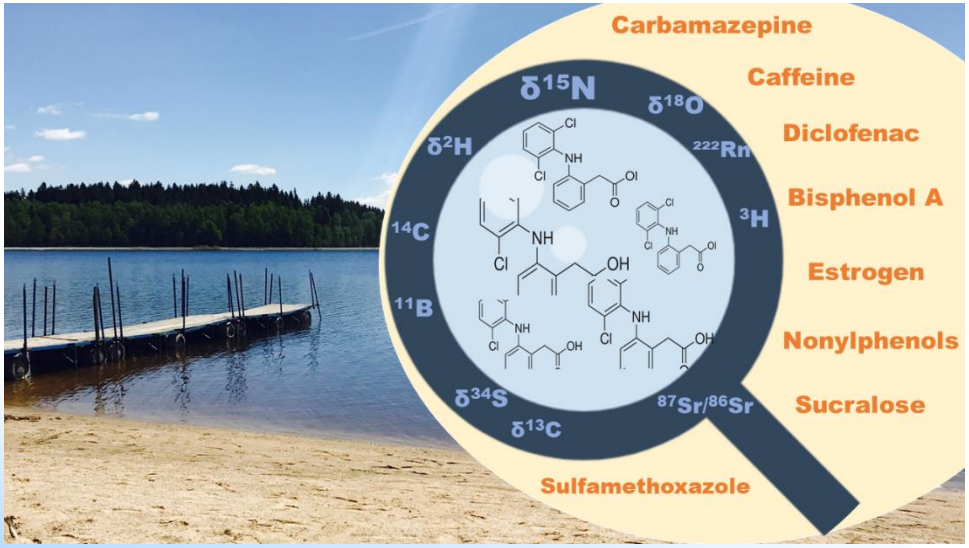
Groundwater from schist formations had the lowest 3H concentrations (1.9 TU) → long residence time and minimal connectivity to surface water and less contamination.

Erostate et al. 2019 Journal of Hydrology

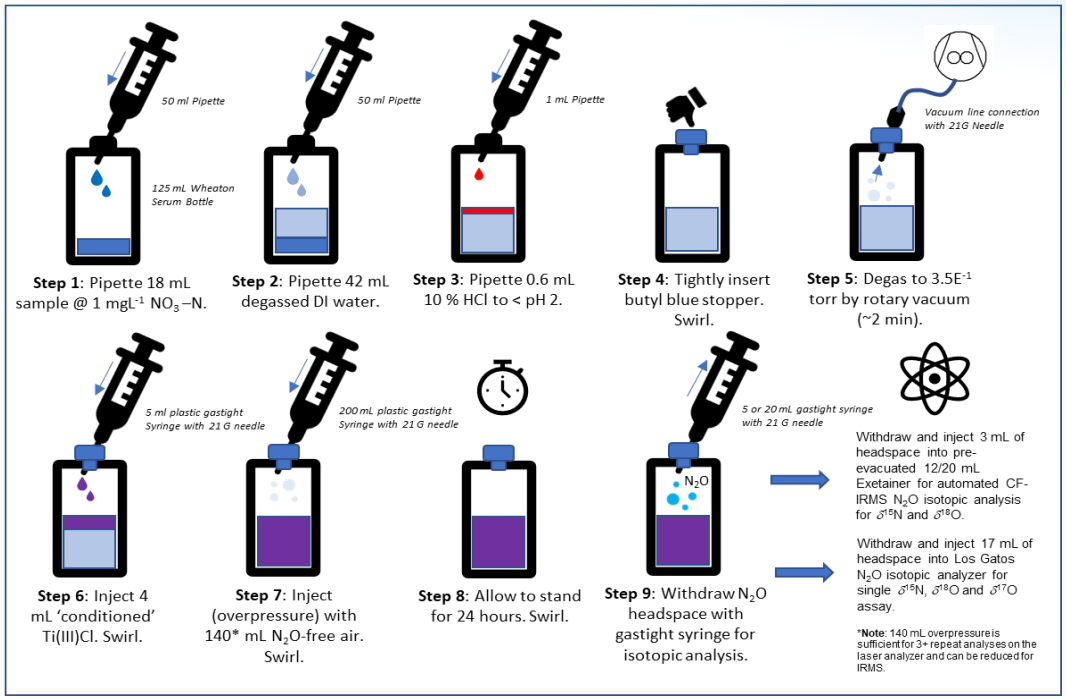
Summary

Linking isotopes and CECs data can be used to:

- **Trace exact pollution sources in groundwater and surface water**
- **Improve understanding of pollutants pathways, e.g. anthropogenic/natural recharge, sewage leakages**
- **Understanding connection between hydrological components**
- **Identify biological processes that impact pollutants in waters**



Isotopes analysis is becoming easier and cheaper but provides important information that cannot be obtained by hydrochemical data



The New Titanium Method to analyse stable nitrate isotopes by Altabet et al. 2019

IAEA CRP 32010 "Improving understanding of nitrate sources in connected river and groundwater systems through linking nitrate isotopes and contaminants of emerging concern" (2021-2024): enhance the capability and expertise among Member States to better assess surface water and groundwater pollution, availability and sustainability and develop a guideline on how the approach can be implemented in different types of water resource evaluations.