

Protection of peri-urban groundwater catchments: a multi-tracer approach for the identification of urban pollution sources

EGU 2022 Congress, Vienna, Austria --- Session HS8.2.8

Laura Balzani*, Philippe Orban & Serge Brouyère

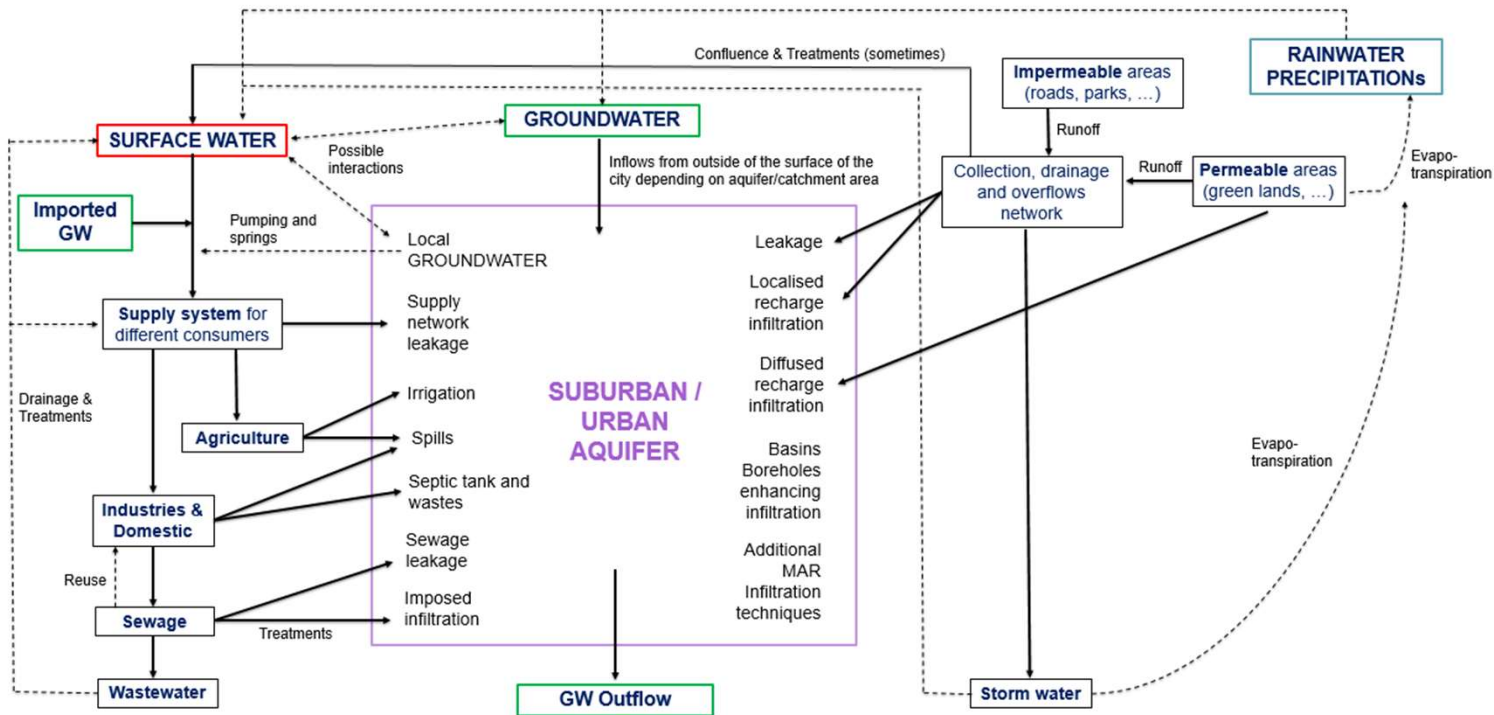
Hydrogeology & Environmental Geology, Urban & Environmental Engineering, University of Liège, Belgium

* Corresponding author (e-mail: laura.balzani@uliege.be)

Thursday, May 26th, 2022

Urban Water Cycle

- **Increase of the impermeable surfaces** due to construction of houses, traffic lanes, car parks, etc.
- **Increase in domestic water consumption despite the water-efficient machines**, increase in n° households/house and comforts (swimming pools, gardens)



Problem

- **Relevant diversity of pollution sources** linked to the **diversity of land use occupation**

Aims

- **Discriminate between different pollution sources** using a range of **tracers and approaches**
- **Decision-making reference system (prioritizing pollution and remediation measures)**

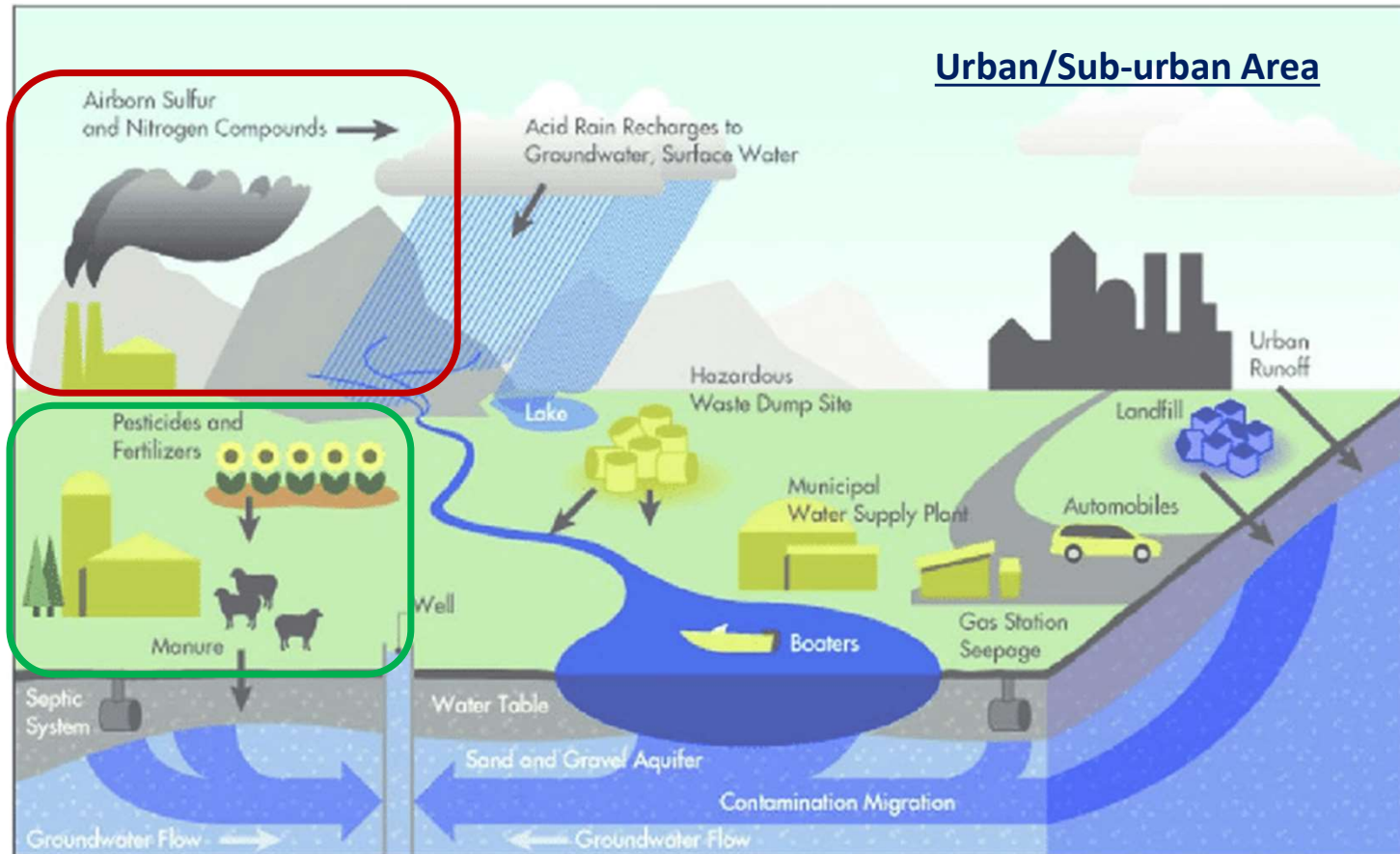
Tracers of different contaminations (origin of pollution)

Industry

Chlorinated Solvents;
Specific reaction reagent-products; Cleaning-rinsing-dusting and gas washing; Suspended solids, Organic matter, **N** and **P** products, toxic substances (flame retardants, ...)

Agriculture

Organic and Artificial-inorganic fertilizers;
Nutrients (**N**, **P**);
Heavy metals (Cd, Cu, Zn, ...);
Herbicides and Pesticides;
Veterinary Animal Pharmaceuticals and Hormones (manure)



Micro-pollutants of road waters : trace metals, total hydrocarbons, PAHs, Cu, Cd, Cr, Fe, Pb, Ni and Zn,

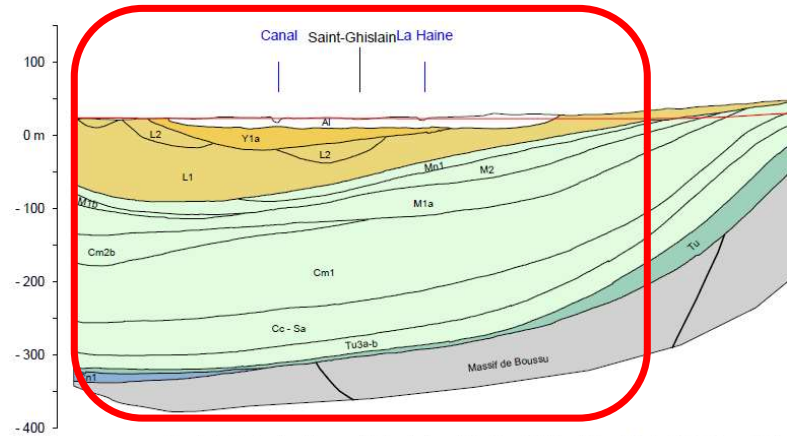
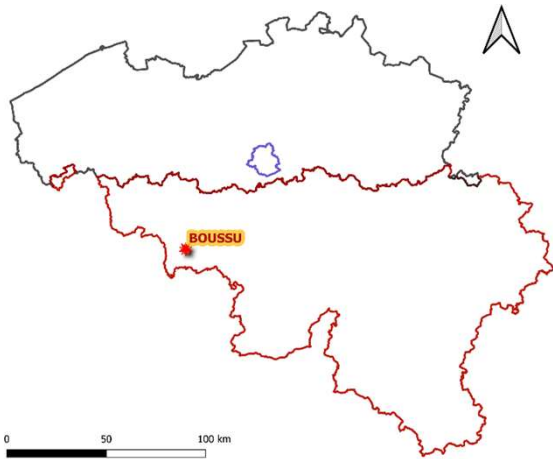
Household wastewaters: EOC (lifestyle compounds; caffeine, nicotine; pharmaceutical substances; detergents), **N** compounds

Hospitals: specific substances as Gd for IRM imaging

Specific dumpsites substances (hazardous wastes, metals, polyfluorinated compounds, ...)

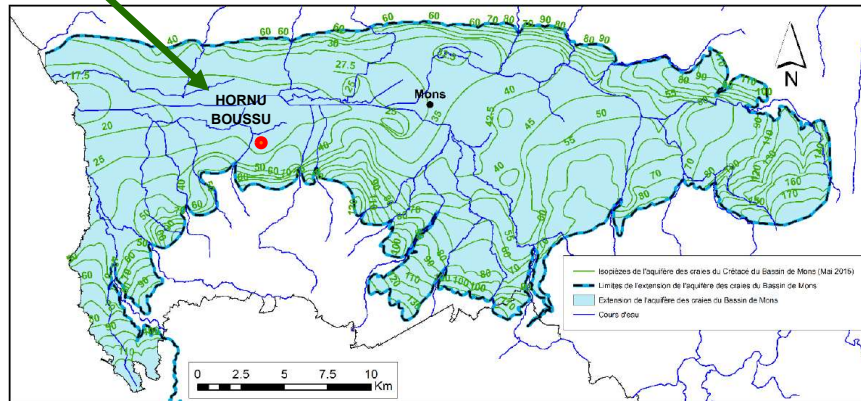
(Berg et al., 2007)

Pilote site: abstraction wells in the cretaceous chalk aquifer in western Wallonia, Belgium

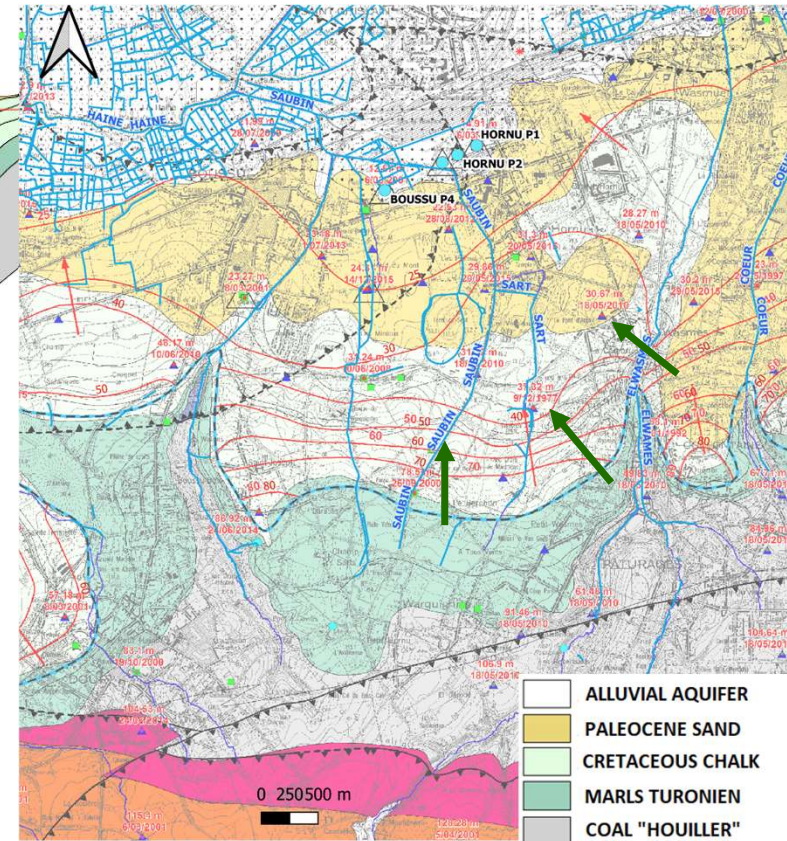


Coupe hydrogéologique d'après la coupe géologique tracée par R. Marière en 1967 et modifiée par A. Rorive et Y. Godfriaux en 1987

Cross section NW-SE



— Isohyètes de l'aquifère des craies du Bassin de Mons (Mai 2019)
 — Limites de l'expansion de l'aquifère des craies du Bassin de Mons
 — Extension de l'aquifère des craies du Bassin de Mons
 — Cours d'eau



- ALLUVIAL AQUIFER
- PALEOCENE SAND
- CRETACEOUS CHALK
- MARLS TURONIEN
- COAL "HOULLER"
- GIVETIEN LIMESTONE
- AQUITARD DEVONIEN

(Bougard et al., 2017)

MAIN POLLUTANTS OF THE CASE STUDY

NITRATE

SULFATES

CHLORINATED SOLVENTS

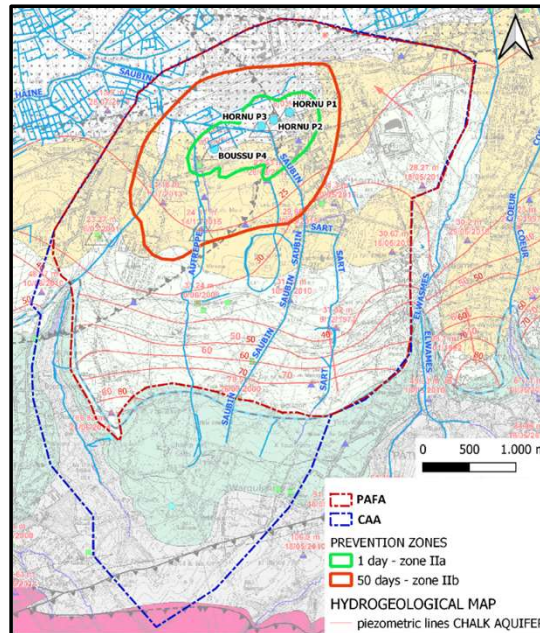
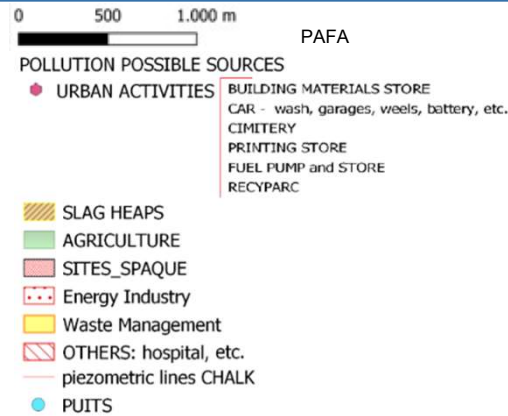
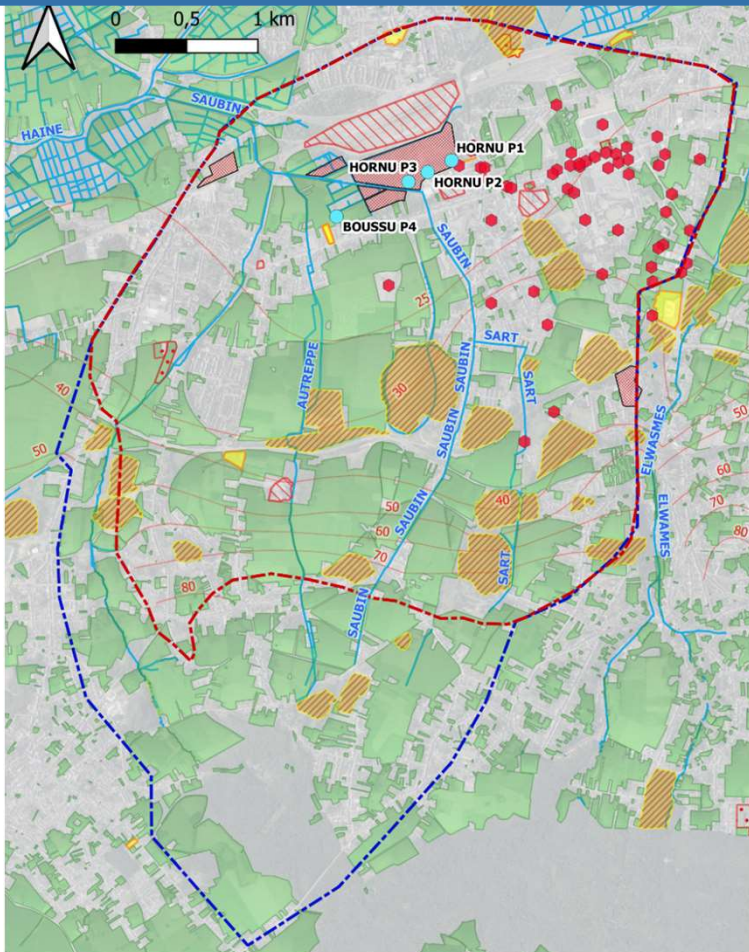
SPECIFIC ANALYSIS PERFORMED

Stable isotopes of NO₃ and Boron to mainly distinguish urban effluents from agricultural fertilisers (Nikolenko et al., 2018; Widori et al., 2005); **Occurrence of pharmaceutical (carbamazepine, etc.) and lifestyle (caffeine, nicotine) products** to identify anthropogenic contamination (Neufcourt, 2017) or **agricultural pesticides-products** and **manure contamination substances**.

Stable isotopes of SO₄ to distinguish anthropic activity, dissolution of evaporates, or alteration of carbon mines waste (Knöeller et al., 2011); **Occurrence of pharmaceutical (carbamazepine, etc.) and lifestyle (caffeine, nicotine) products**; and **Occurrence of Gd (REE)** used as a contrast agent in magnetic-resonance imaging, therefore suitable to verify contamination by anthropic wastewater and hospitals (Boester et Rude, 2020; Petelet-Giraud et al., 2009) .

Isotopes of Chlorinated Solvents to check if natural attenuation/degradation is happening and try to get closer to the location of their point source/origin (Akesson et al., 2021; Elsner et al. 2005); **Microbiological and bacteriological analysis** to make an inventory of all the microbial/bacterial species present in the samples and verify hypothesis on the occurrence of denitrification, sulfur reduction/oxidation, chlorinated solvents degradation, etc. (Kanohin F. et al., 2018; Kumar et al., 2014)

Catchment area: sampling campaigns



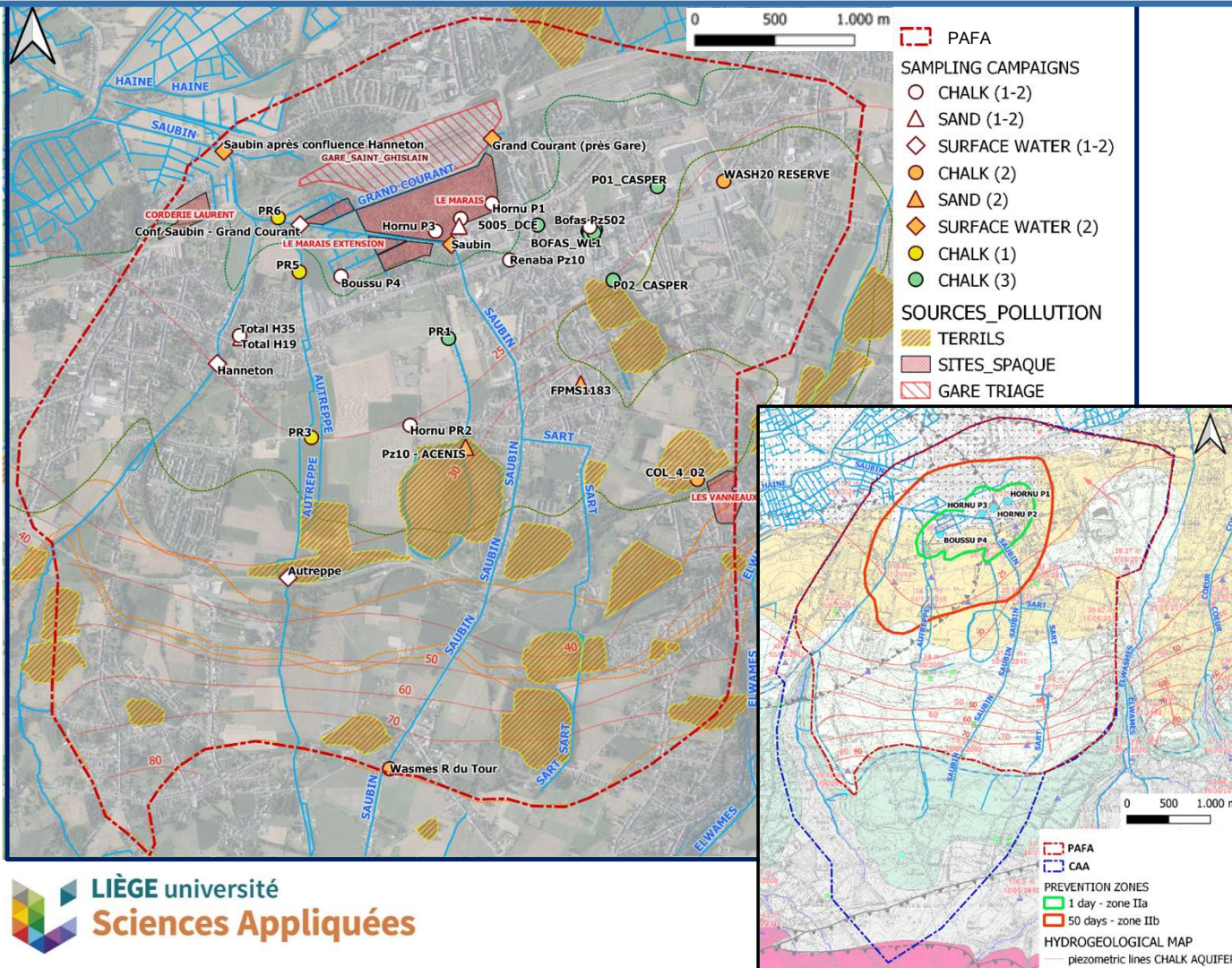
Groundwater Catchment Area of Abstraction

(investigations focused in PAFA – part of aquifer feeding the abstraction)

List of sources of potential pollution (old dumps and slag heaps, railway wastes, discharges, hospitals, housing and agriculture, energy-industrial activities)

Different sampling campaigns

Catchment area: sampling campaigns



Groundwater Catchment Area of Abstraction

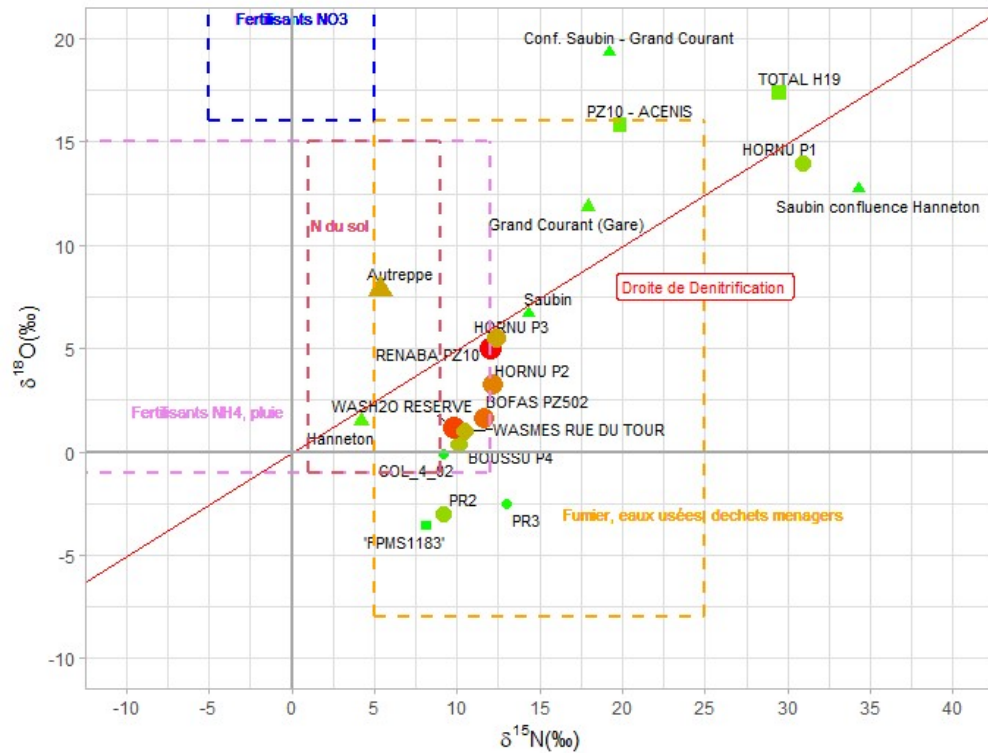
(investigations focused in PAFA – part of aquifer feeding the abstraction)

List of sources of potential pollution

(old dumps and slag heaps, railway wastes, discharges, hospitals, housing and agriculture, energy-industrial activities)

Different sampling campaigns

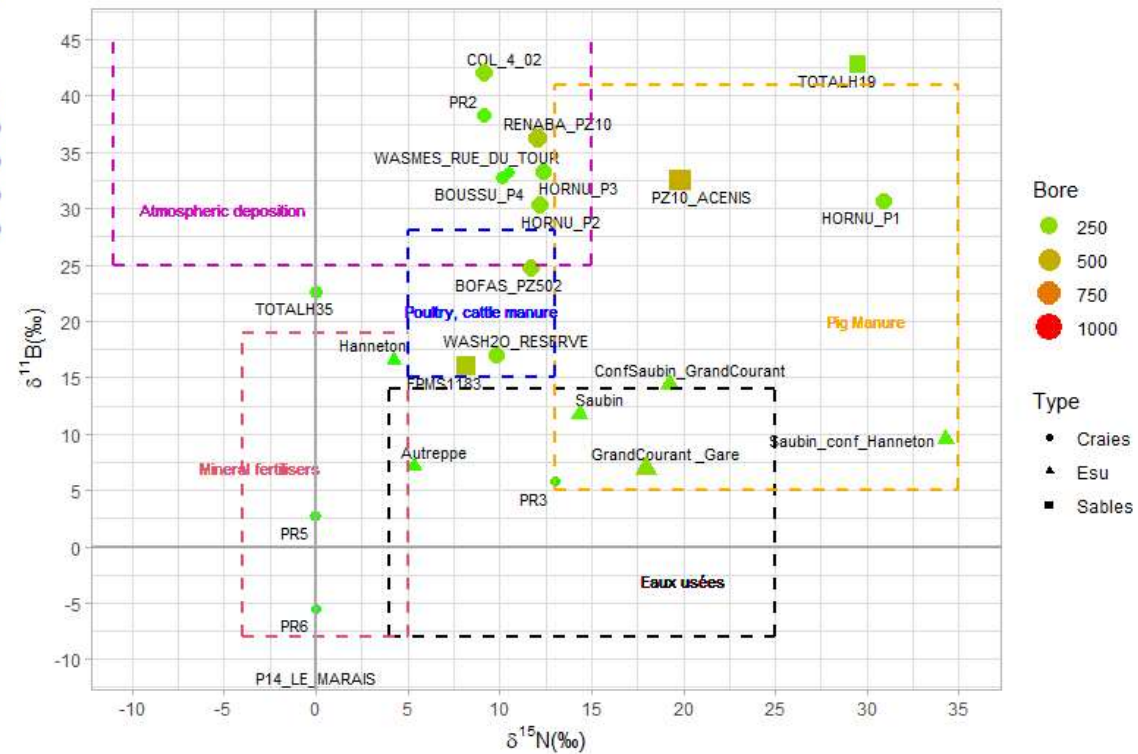
NO₃ and isotopes (results from 2021)



Type
 • Craies
 ▲ Esu
 ■ Sables

NO3
 ● 0
 ● 20
 ● 40
 ● 60
 ● 80

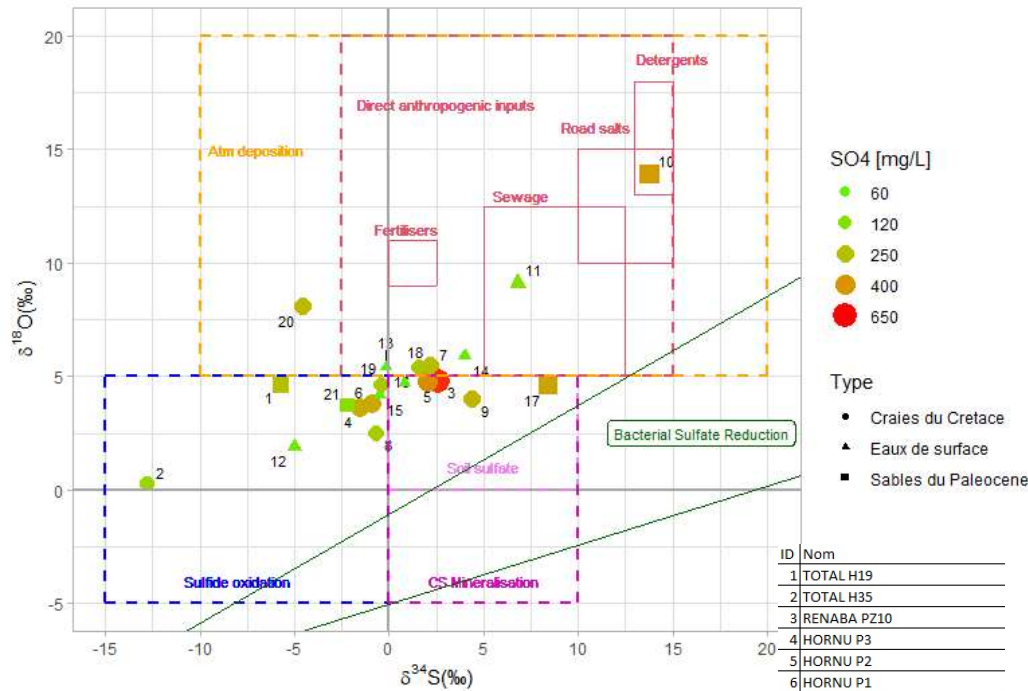
- Evidence of denitrification (correlation with [Se])
- Mixture: wastewater vs agriculture



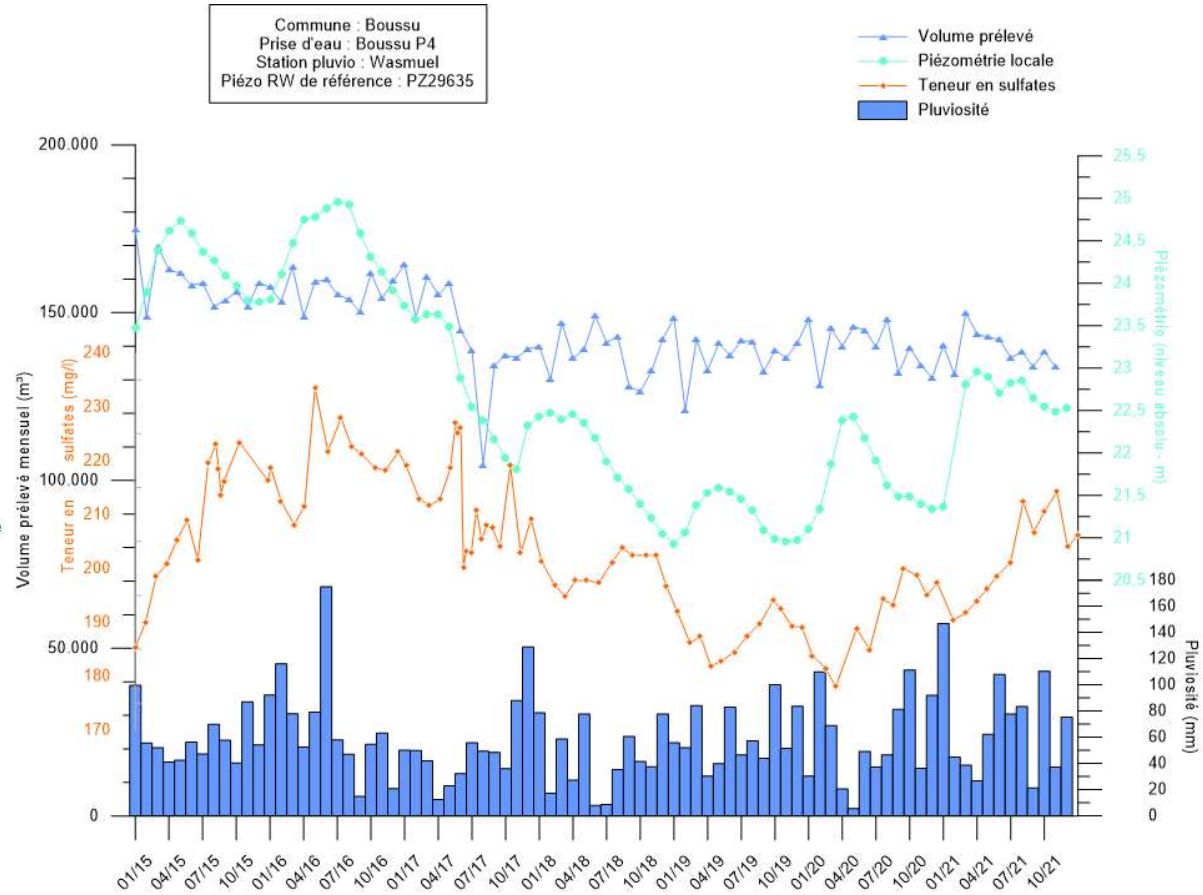
Bore
 ● 250
 ● 500
 ● 750
 ● 1000

Type
 • Craies
 ▲ Esu
 ■ Sables

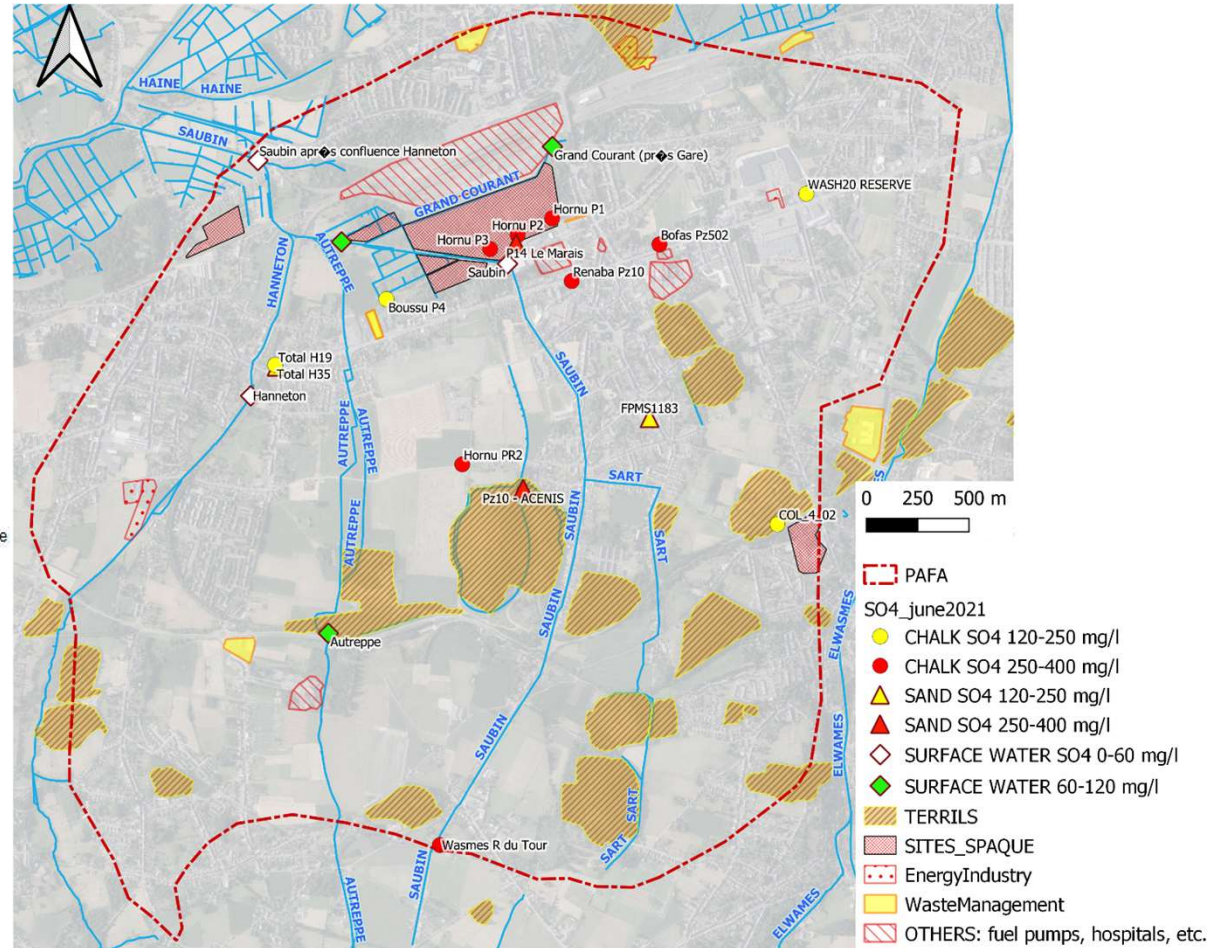
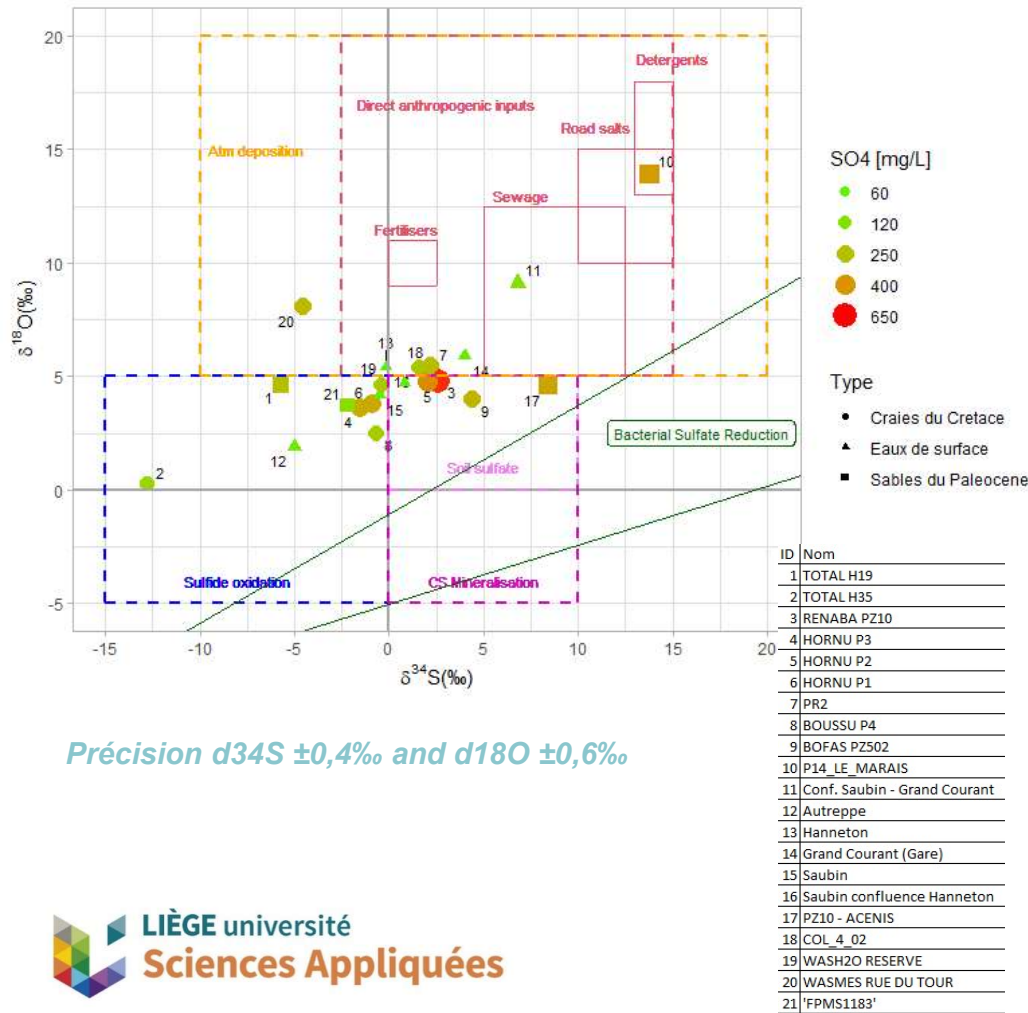
SO₄ and isotopes (results from summer 2021)



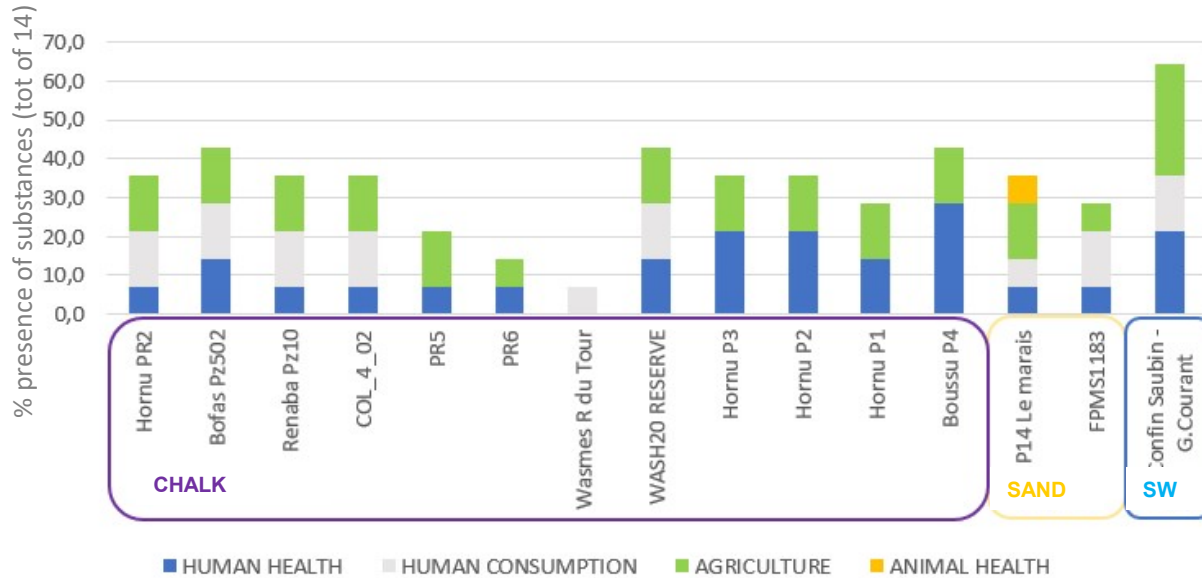
Précision d34S ±0,4‰ and d18O ±0,6‰



SO₄ and isotopes (results from summer 2021)



Pharmaceuticals substances (results 2021)



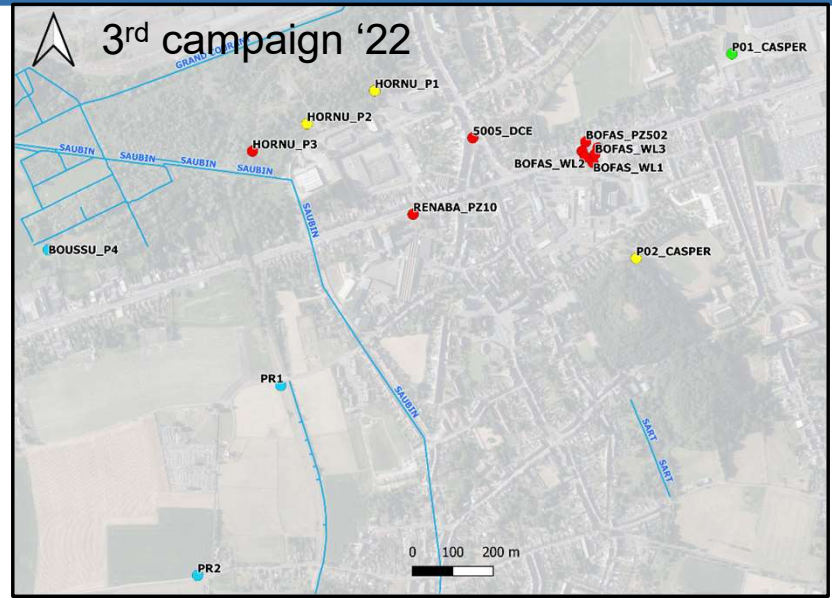
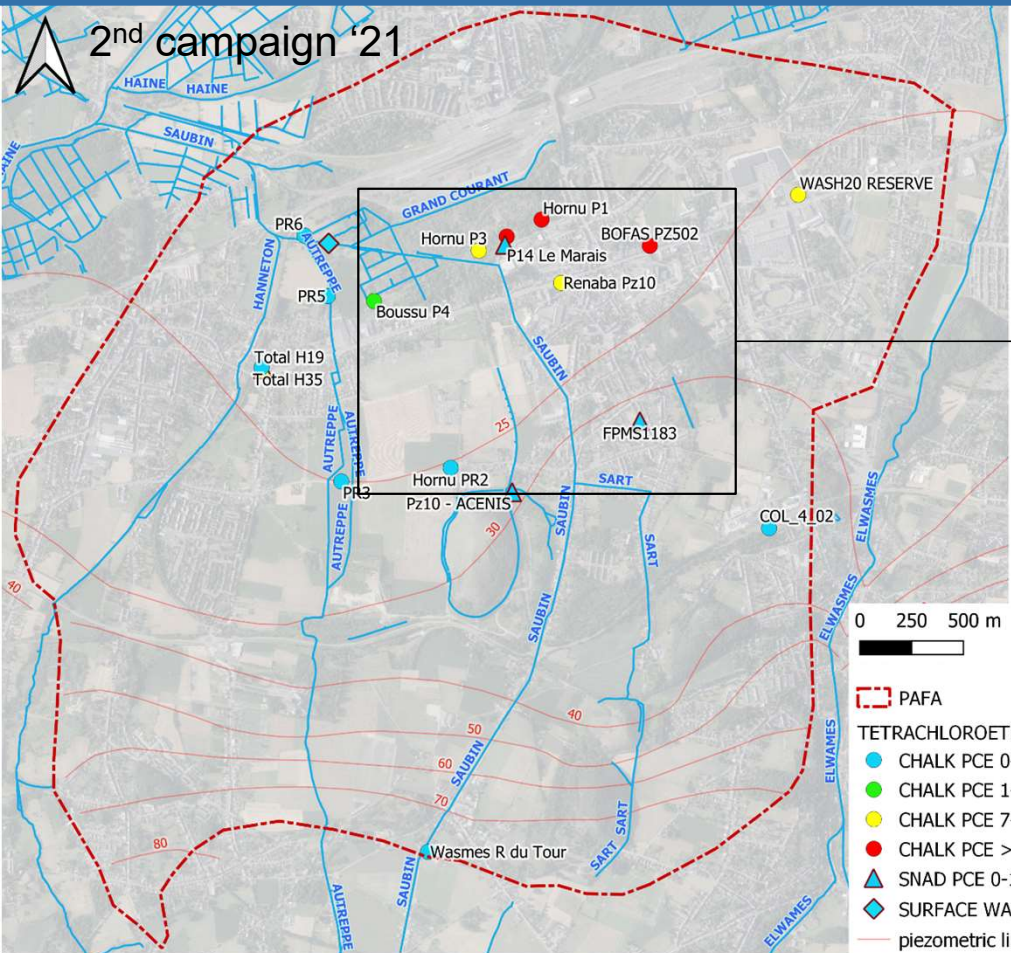
Used mainly as a proof of hypothesis contamination's origin

Selection of few substances for each of the 4 categories analysed

To couple with Gd presence

HUMAN HEALTH	HUMAN CONSUMPTION	AGRICULTURE	ANIMAL HEALTH
Carbamazépine	Caféine	Bentazone	Sulfaméthazine
Hydrochlorothiazide	Cotinine	MCPA	Clorsulon
Paracétamol		Isoproturon	Dicyclanil
Sulfaméthoxazole		Diclorobenzamide	Florfenicol

Chlorinated Solvents (summer 2021 → spring 2022)



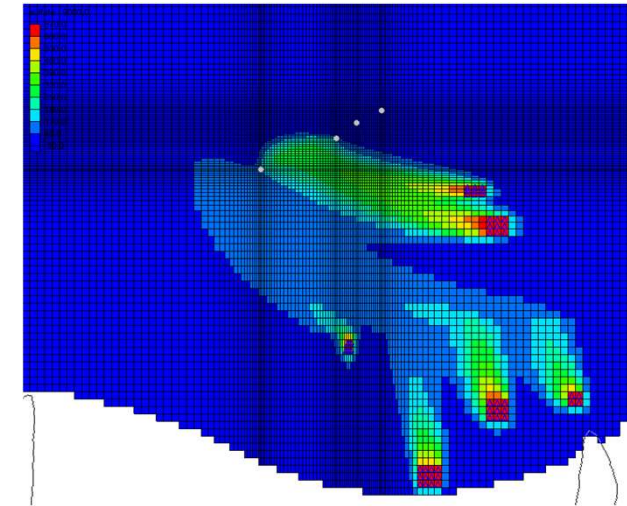
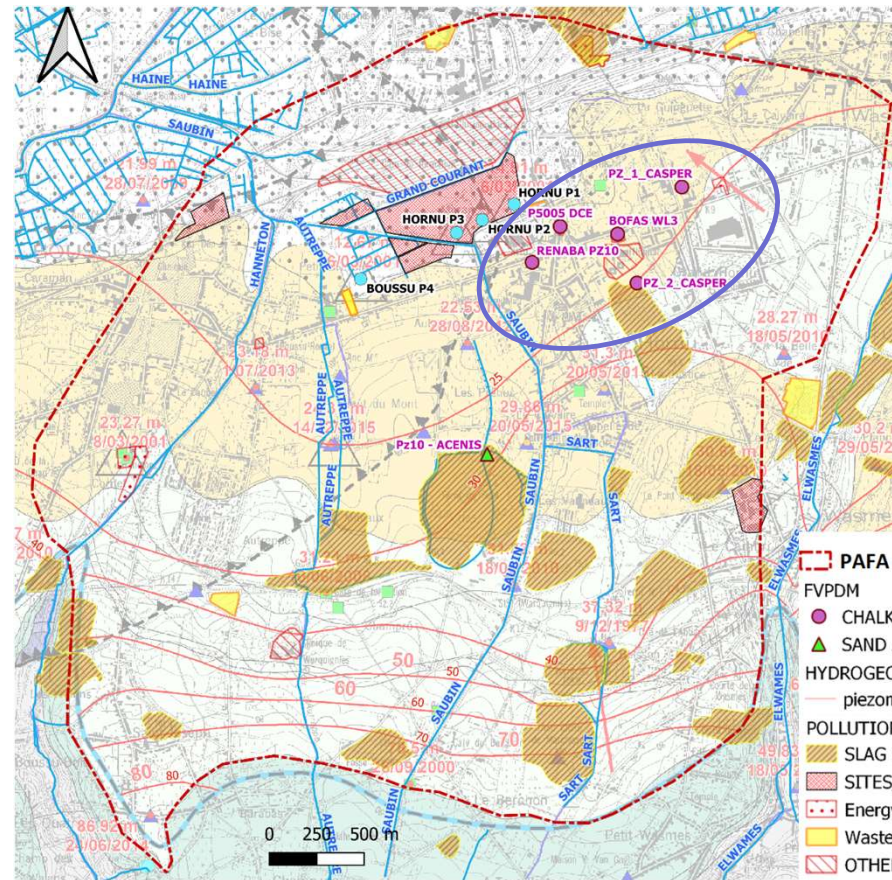
Mainly:
PCE, DCE,
TCE, TCA

To go further:

- Analysis on gradient concentrations and molar ratio
- Research of historical activities in the site
- Plume behaviour
- **Degradation – isotopes C, H, Cl and microbiological analysis**

Following steps to go further...

- Measures of gw fluxes
- Modelling
- Development of tools to prioritize investigation and remediation measures



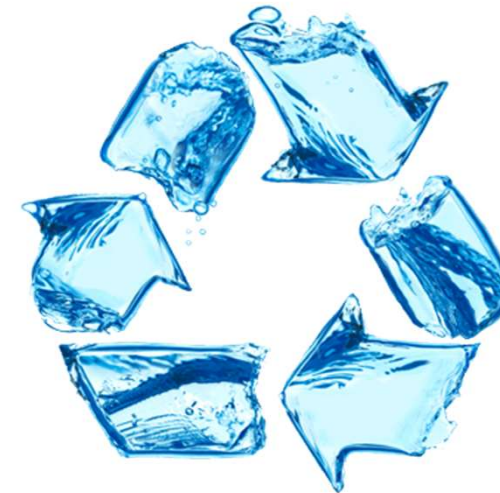
- PAFA
- FVPDM
- CHALK AQUIFER
- SAND AQUIFER
- HYDROGEOLOGICAL MAP
- piezometric lines CHALK
- POLLUTION POSSIBLE SOURCES
- SLAG HEAPS
- SITES_SPAQUE
- Energy Industry
- Waste Management
- OTHERS: hospital, fuel pump, etc.

Acknowledgement

- Société Publique de Gestion de l'Eau – SPGE for financing the project



- CASPER project partners for collaborations and discussions



Thank you for your attention