Institut des Sciences de la Terre d'Orléans

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Sous les tutelles

Université d'ORLÉANS | cnrs | Géosciences pour une Terre durable brgm

# CafeT'Observil

**30 juin 2023**

Beulie pond

TRANSAT

Région Centre-Val de Loire


## Amélie HUMBRECHT

1st year PhD student


Observil

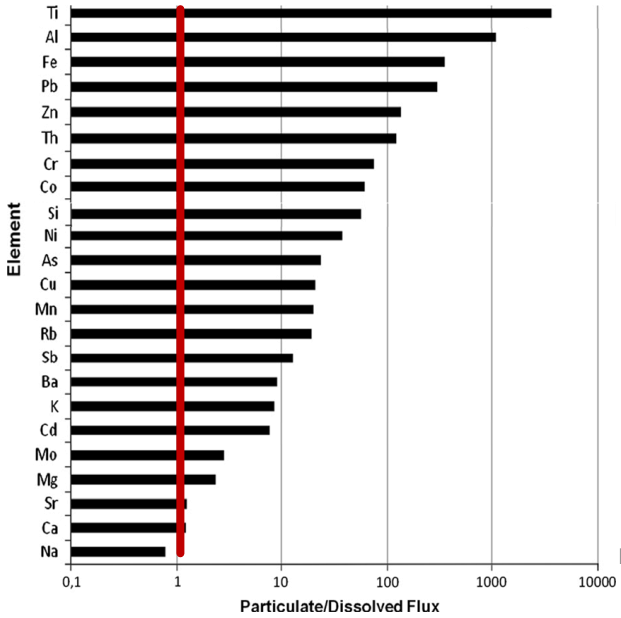
# Réponse spatiale de contaminants organiques et inorganiques d'origine anthropique à l'échelle de l'étang de la Beulie, Egoutier, France


PhD director: Lydie LE FORESTIER

Co-Supervisor : Anaëlle SIMONNEAU

# Context of the study

- One of the Water Framework Directive initial objectives -> reach waterbodies' good ecological state before 2015 -> due date postponed to 2027




~80% occur in the particulate phase, including suspended particulate matters -> considered themselves as contaminants

(Oelkers et al., 2011 and included references, modified by Ledieu, 2020)

- **Inorganic ones** -> trace metals mostly, also studied in the particulate phase (Demlie et al. 2006; Farag et al. 2007)
- **Organic ones** -> particulate phase not always targetted (Bound et al. 2006; Meyer et al. 2006)

- Mostly anthropogenic releases
- Wastewater Treatment Plants : not only trace metals, also organic molecules

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~80% occur in the particulate phase, including suspended particulate matters -> considered themselves as contaminants

(Oelkers et al., 2011 et références [illegible])

**We should not only focus on the bulk matrix -> decompose sediments and identify what the reactive phases are transporting (**Tablin 2018**)**

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- **Organic ones** -> particulate phase not always targetted (Bound et al. 2006; Meyer et al. 2006)

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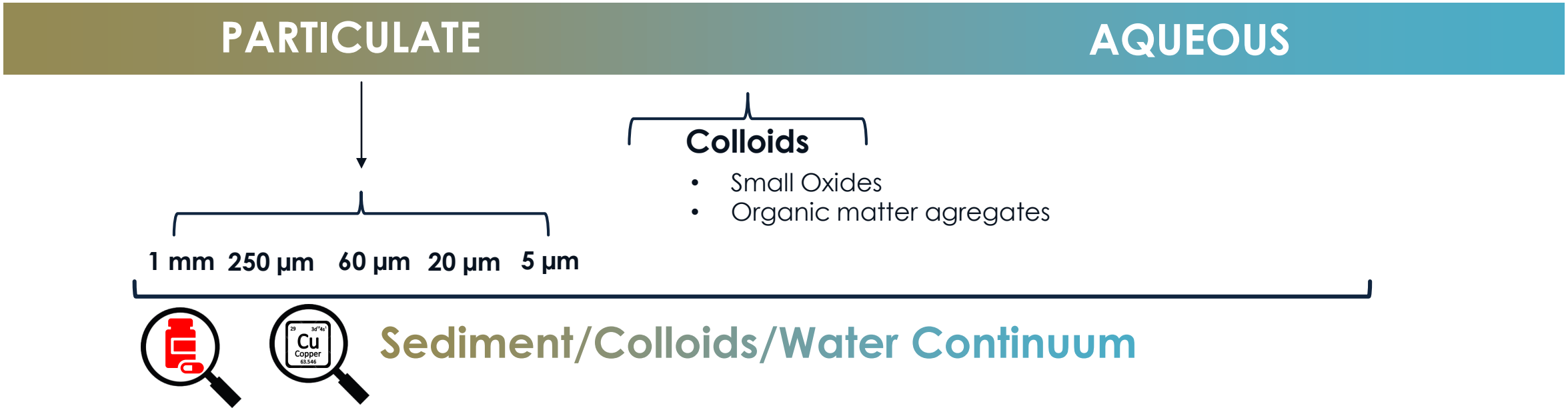
# Context of the study

- **What we already know:**

**->** Organic and inorganic contaminants are released in hydrosystems at sometimes high levels of concentration, and are, for lot of them, also quantified in the particulate phase

- **What we are looking for:**

-> Which compartments are the most likely to adsorb those substancies ? What are the involved mechanisms ?
-> Are those processes reversible ?
-> What is the fate of these contaminants at catchment scales ?



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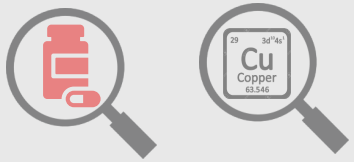
**On the one hand : The most reactive matrices**

**On the other hand : The most reactive systems**

**Colloids**

- Small Oxides
- Organic matter agregates

1 mm 250 µm 60 µm 20 µm 5 µm






**Sediment/Colloids/Water Continuum**

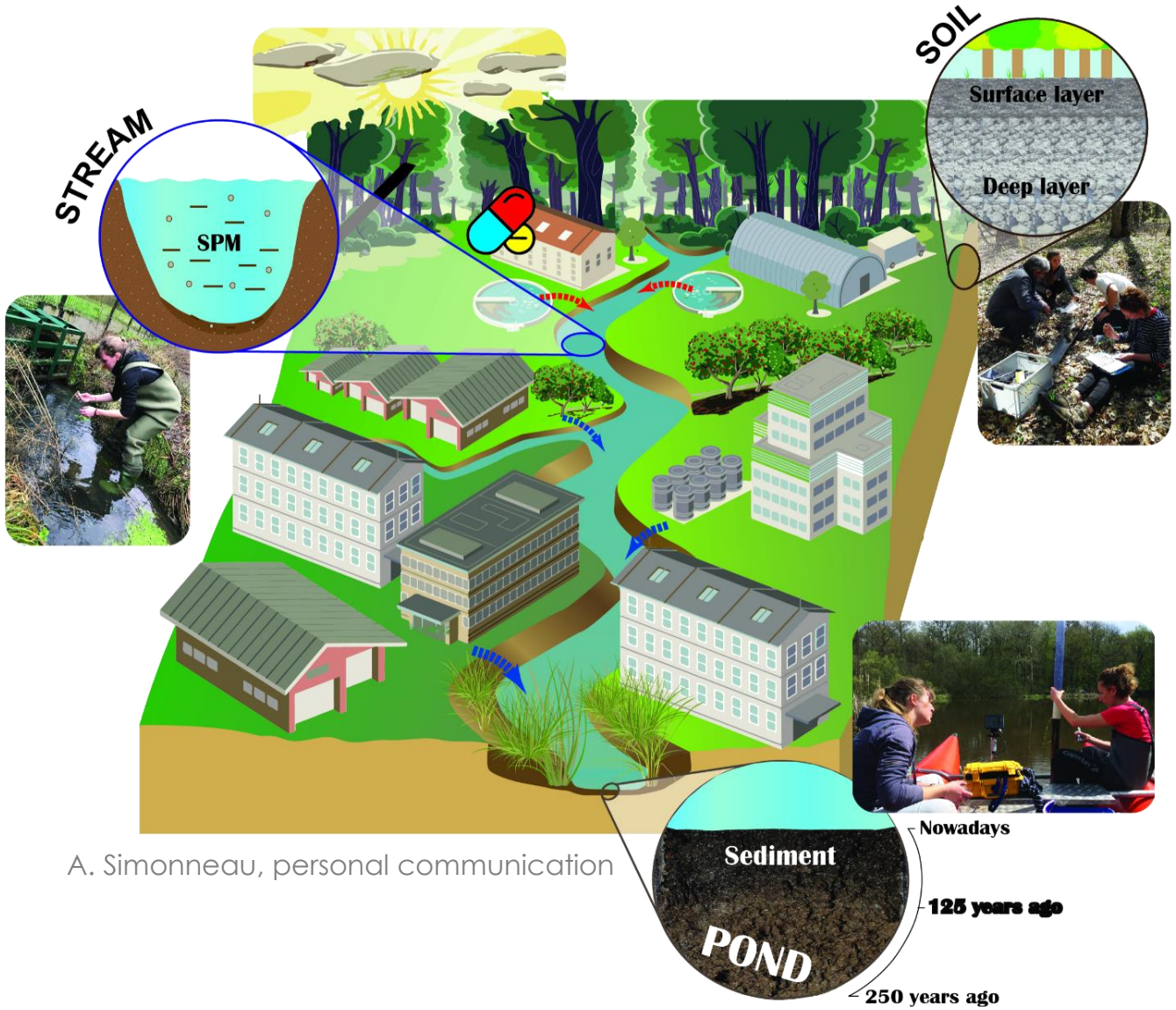
# What would be the perfect candidate?

- 1 watershed subjected to anthropogenic releases
- Anthropogenic contaminants transfers' studies imply also a focus on small hydrosystems -> more sensitive/ vulnerable (Boulard et al. 2022)
- 1 retention area -> favours particulate fluxes storage (accumulation), and consequently adsorbed contaminants

# Context of the study

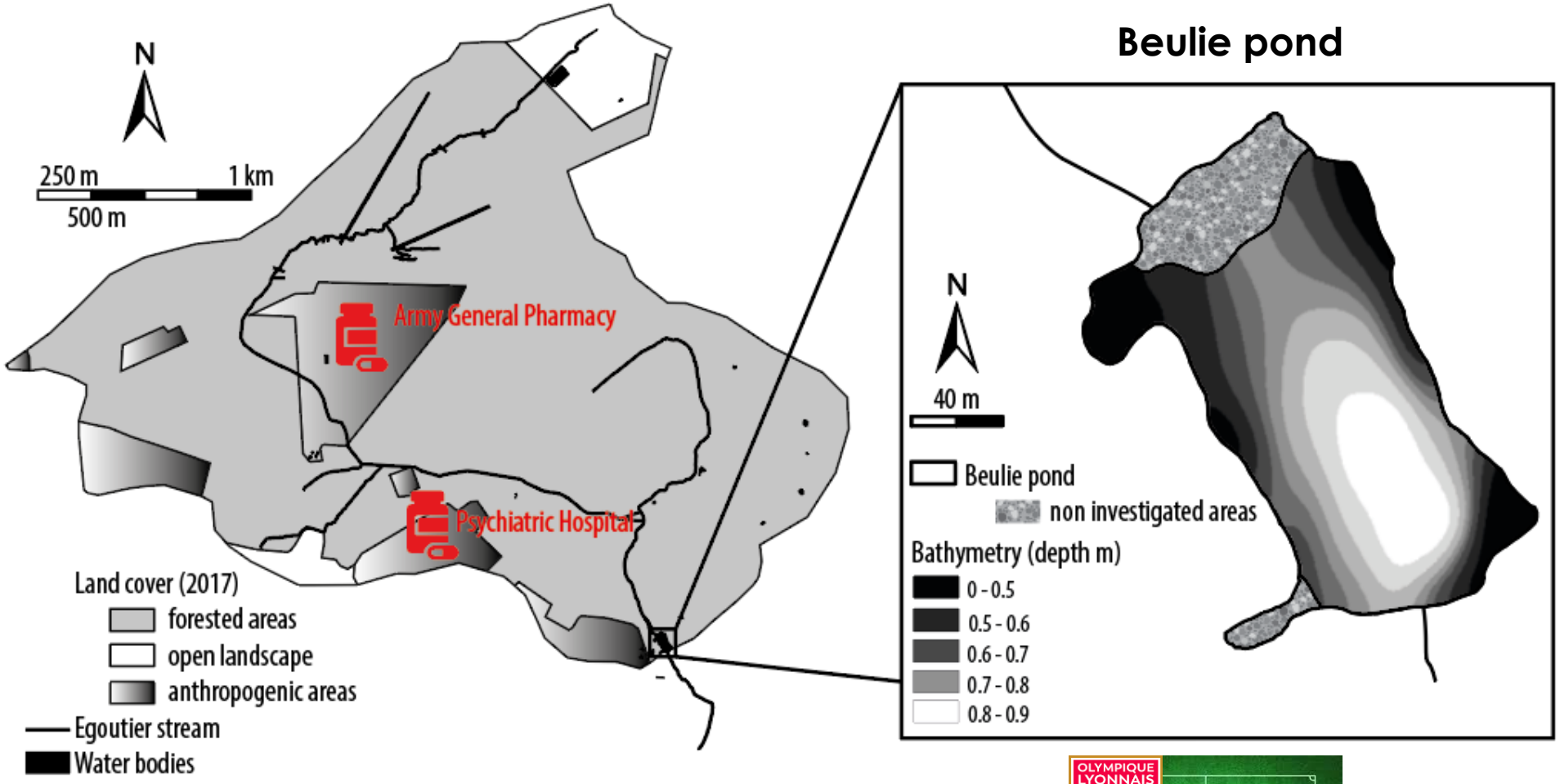
- Release of inorganic and organic contaminants through wastewater treatment plants (WWTP) (red arrows) or other anthropogenic sources (blue arrows)

- Focus not only made on streams reaching outlets, but also on mass collected in retention areas, within hydrosystems




A. Simonneau, personal communication

## Instrumented Egoutier Watershed (Loiret, France)



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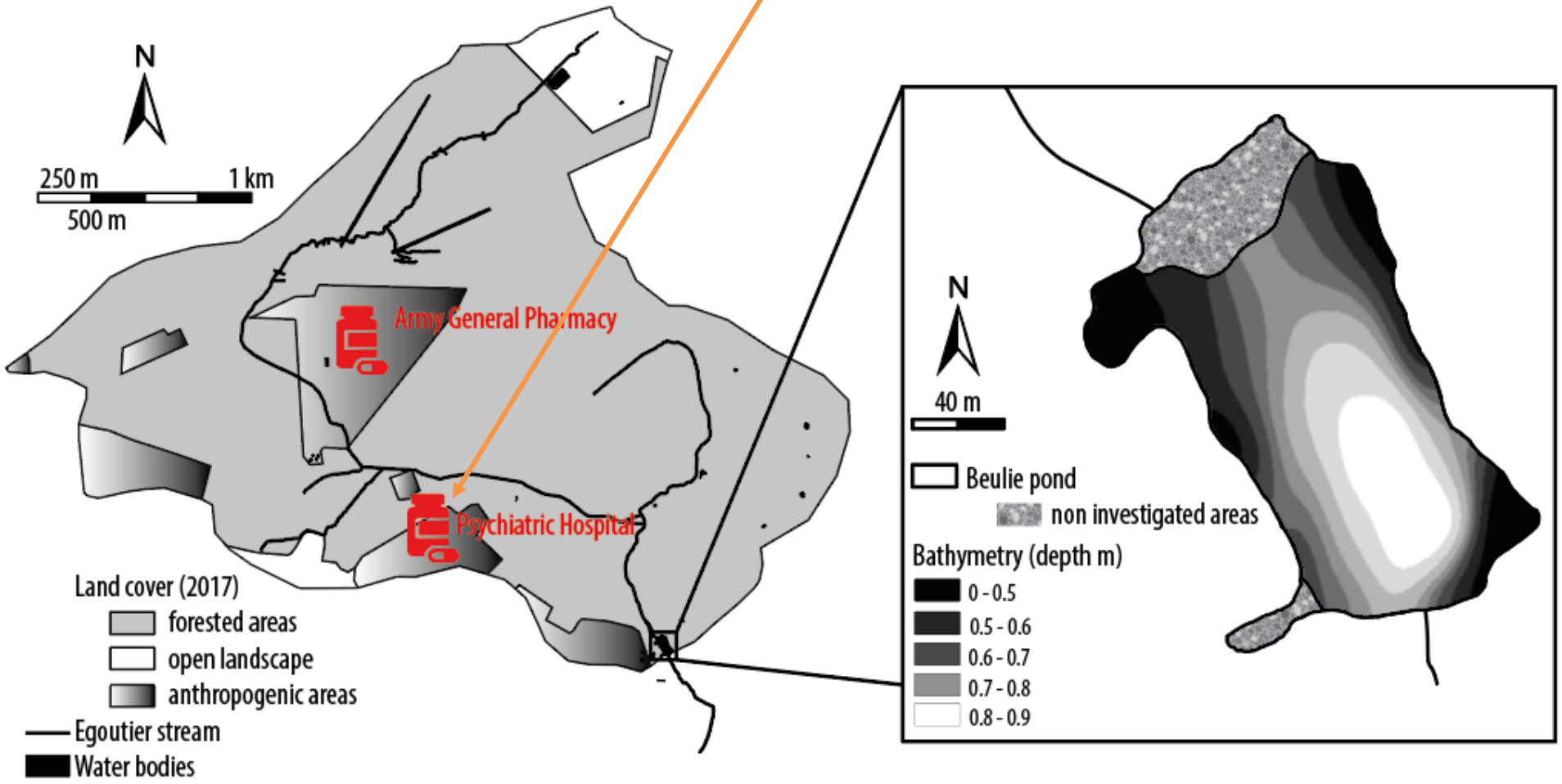
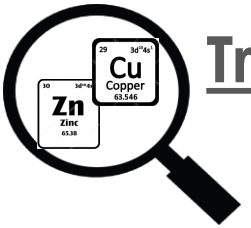
# Trace metals

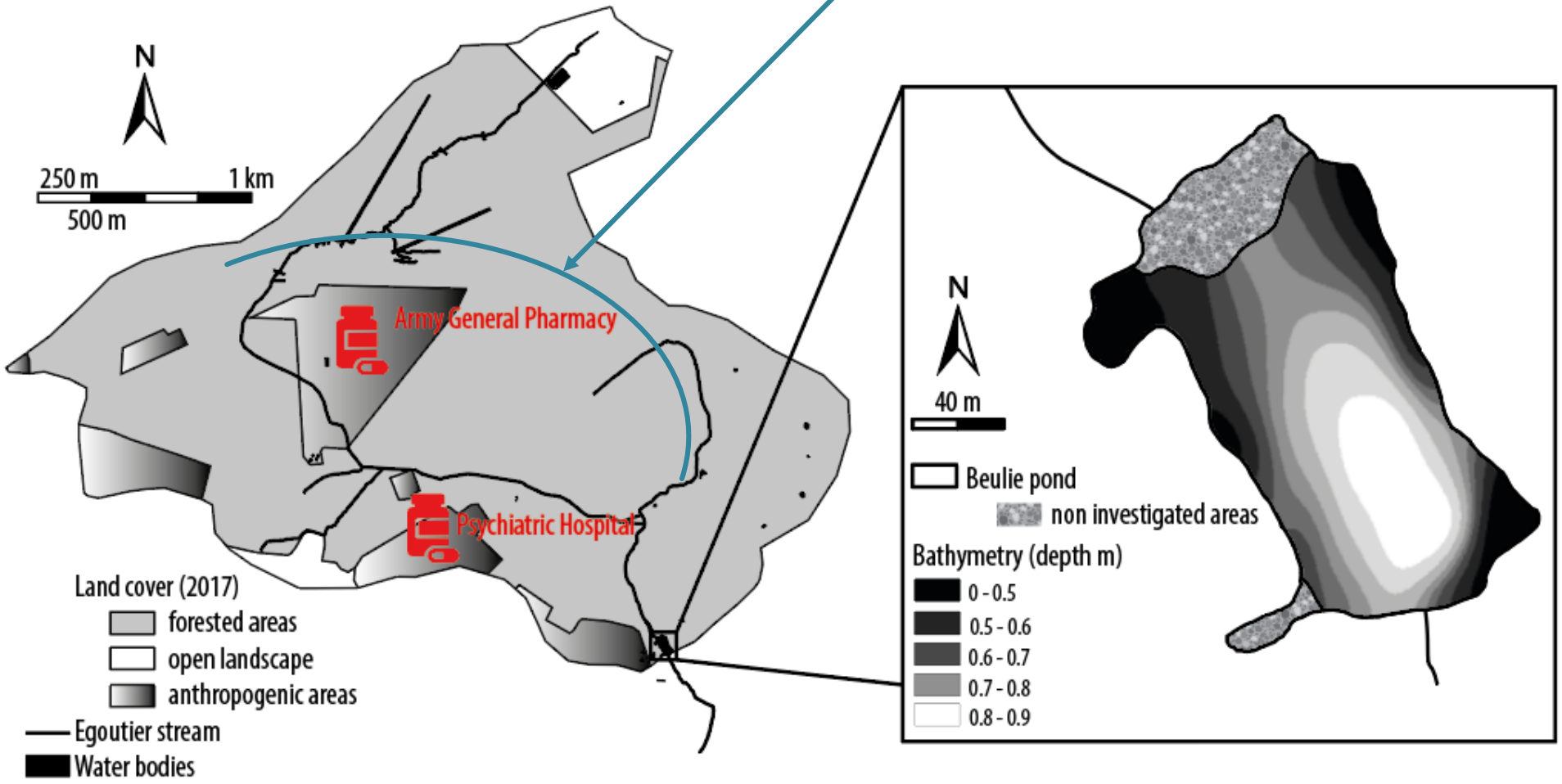
Copper (Cu) : Psychiatric hospital's laundry (Ledieu 2020)





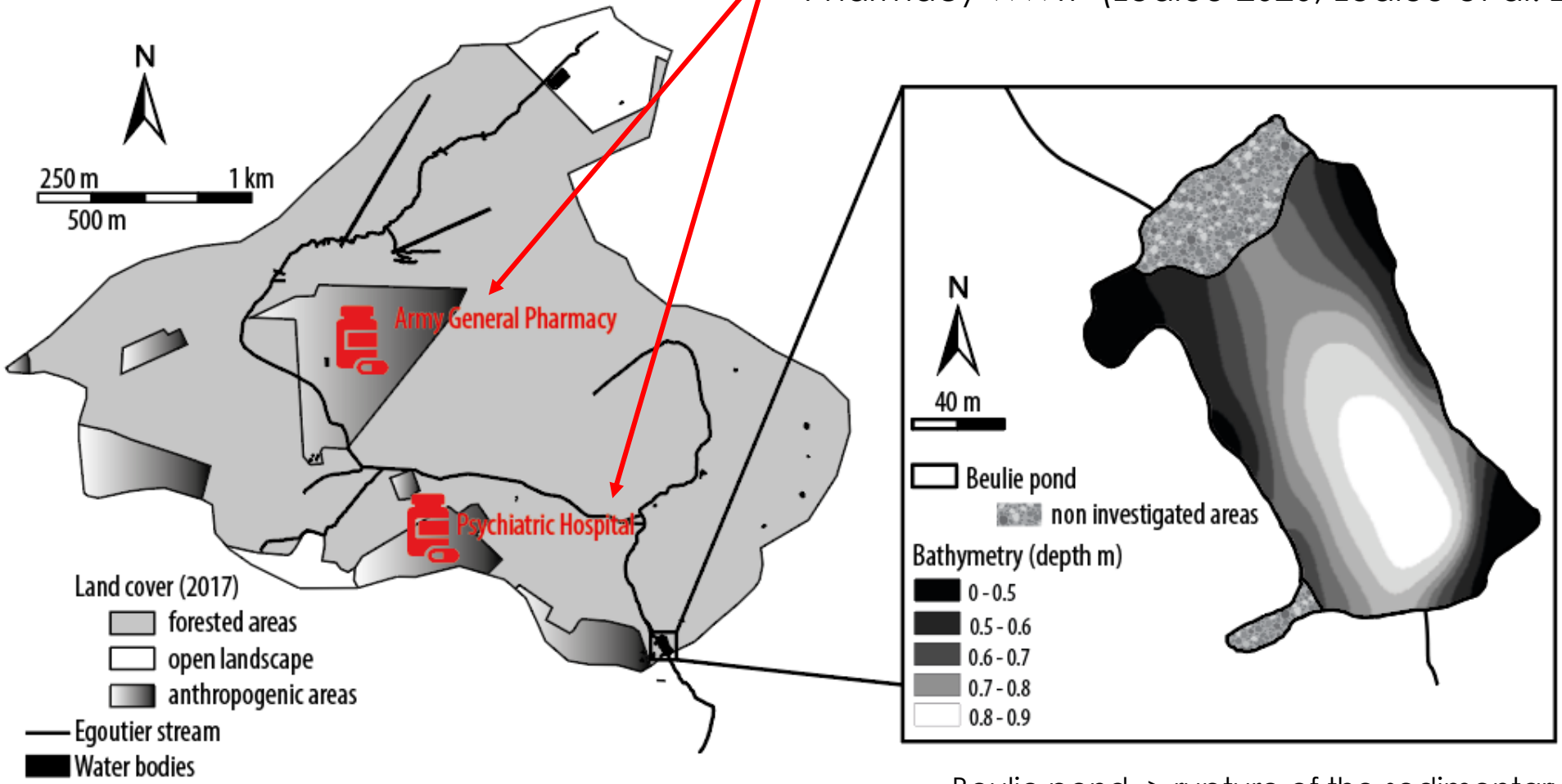

# Trace metals

Zinc (Zn): Guardrails (Ledieu 2020)



# Organic molecules

**Pharmaceuticals:** Psychiatric hospital and Army General Pharmacy WWTP (Ledieu 2020, Ledieu et al. 2021)

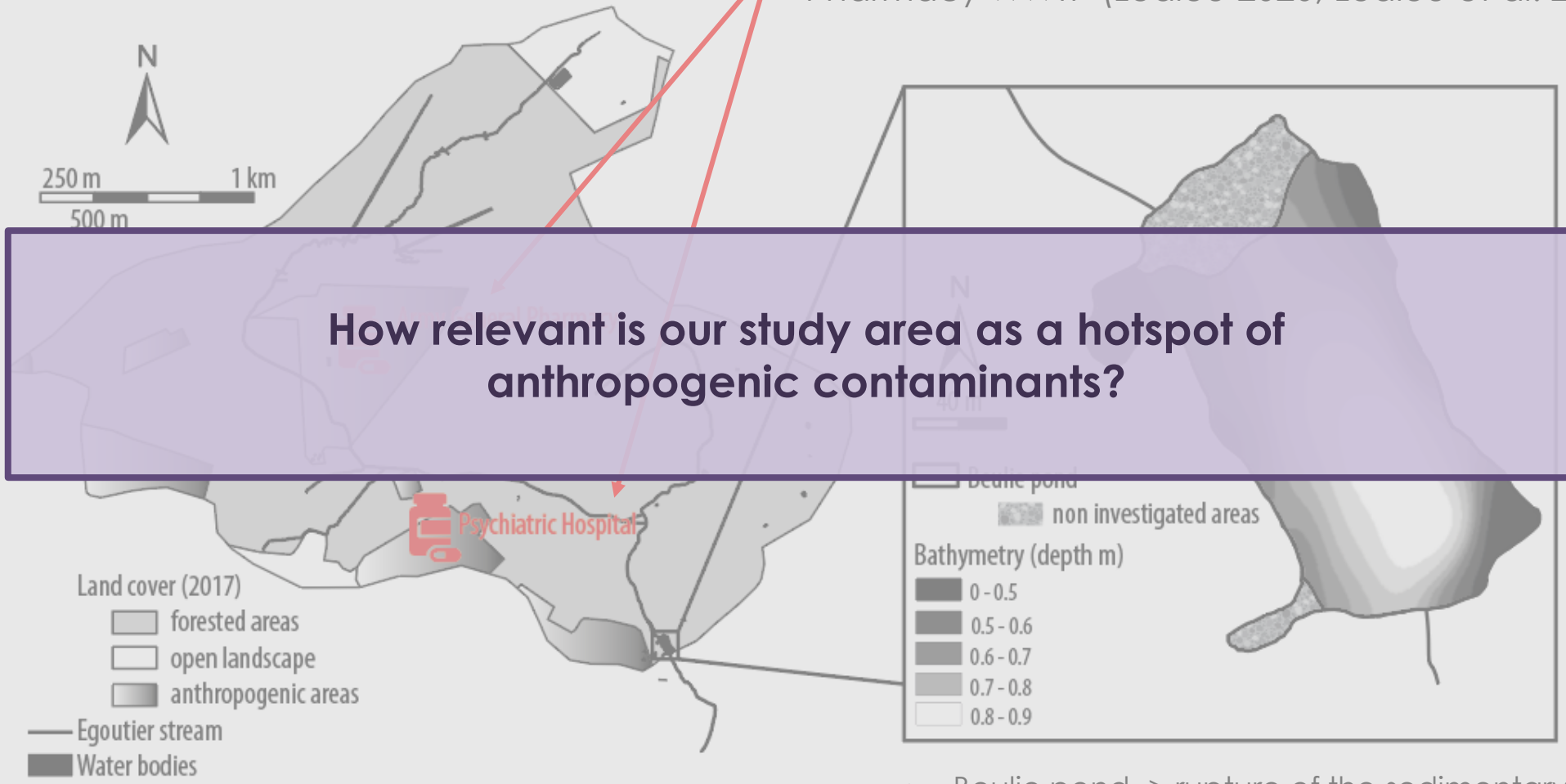



- Beulie pond -> rupture of the sedimentary cascade
- Accumulation area -> one of the contamination hotspots (Ledieu et al. 2021)

# Organic molecules

**Pharmaceuticals:** Psychiatric hospital and Army General Pharmacy WWTP (Ledieu 2020, Ledieu et al. 2021)

**How relevant is our study area as a hotspot of anthropogenic contaminants?**




- Beulie pond -> rupture of the sedimentary cascade
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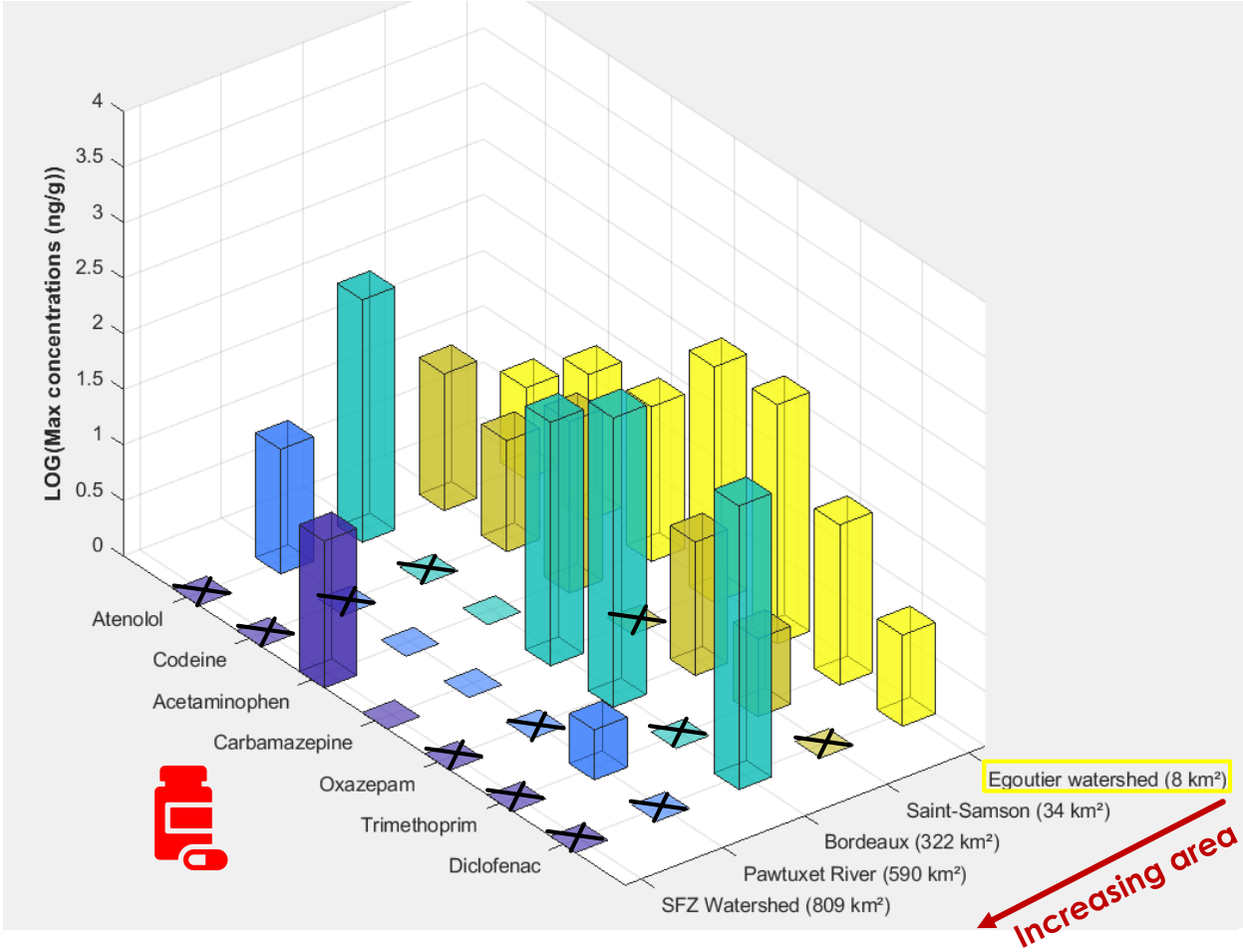
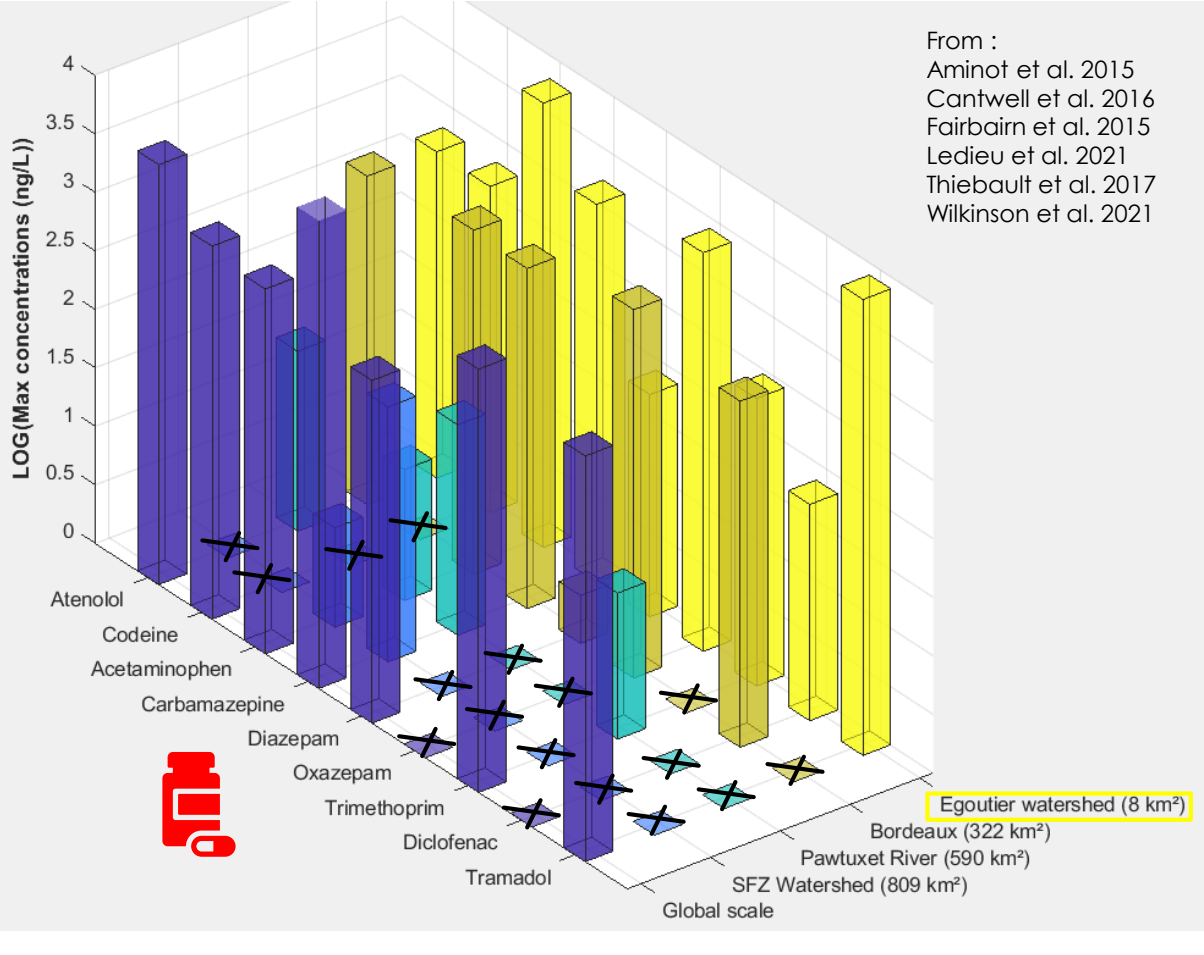
## PARTICULATE

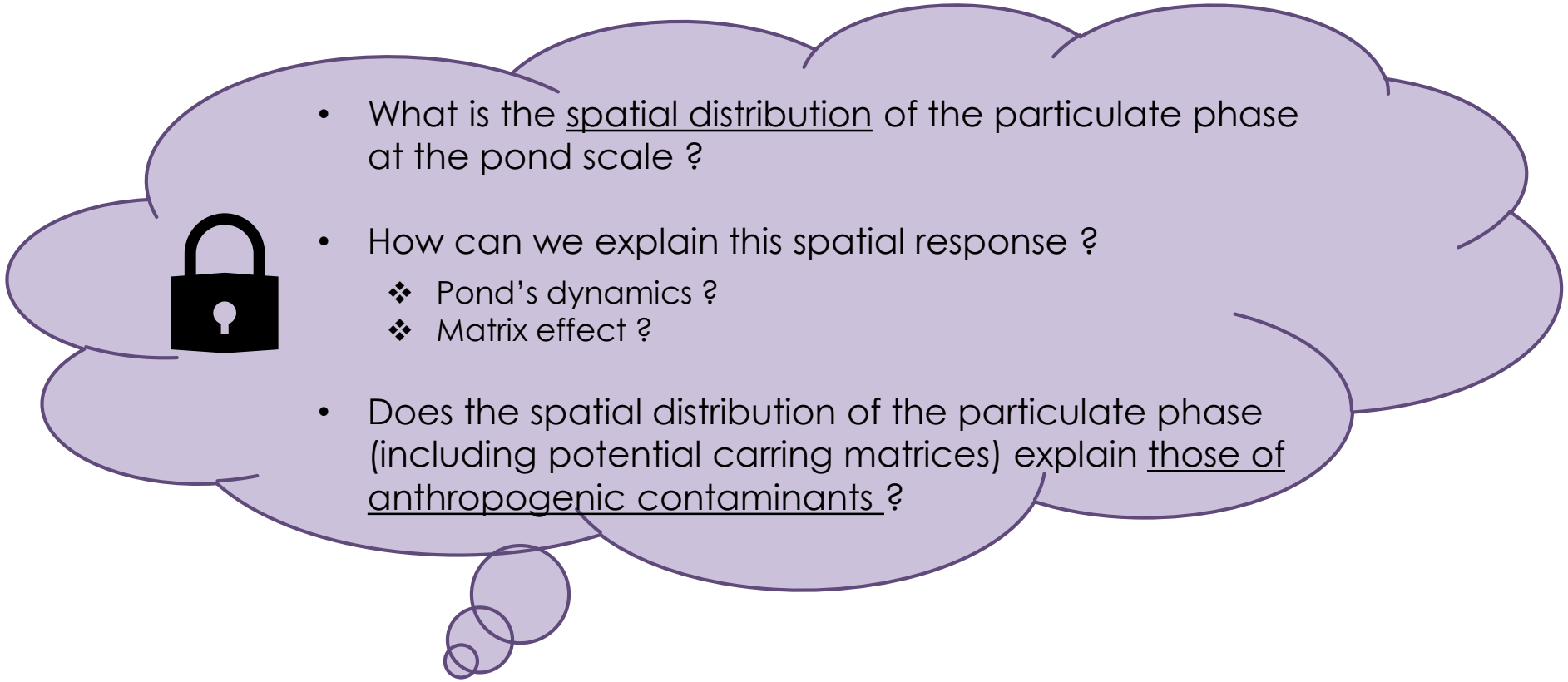
## AQUEOUS



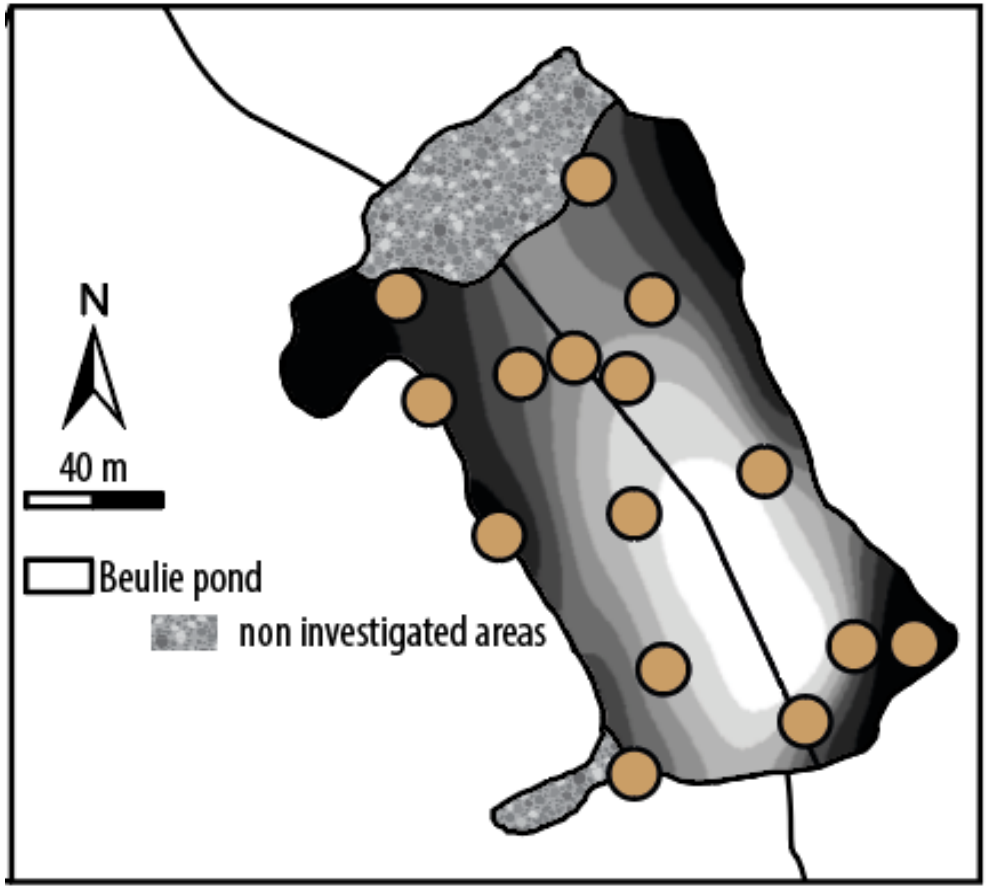




From :
Aminot et al. 2015
Cantwell et al. 2016
Fairbairn et al. 2015
Ledieu et al. 2021
Thiebault et al. 2017
Wilkinson et al. 2021

The Egoutier watershed is subjected, as well in the aqueous as in the particulate phases, to pharmaceutical molecules contents similar to those registered in other suburban catchments



- What is the spatial distribution of the particulate phase at the pond scale ?
- How can we explain this spatial response ?
  - Pond's dynamics ?
  - Matrix effect ?
- Does the spatial distribution of the particulate phase (including potential carring matrices) explain those of anthropogenic contaminants ?




## SAMPLING (Sediment retrieving)

- 15 interface sediment samples collected in September 2021 using an Ekman grab

## SEDIMENT SAMPLES CHARACTERIZATION

### Granulometric and mineralogical characterizations

- Particles sizes and distribution within sediments
- Fine particles content

} Laser granulometry

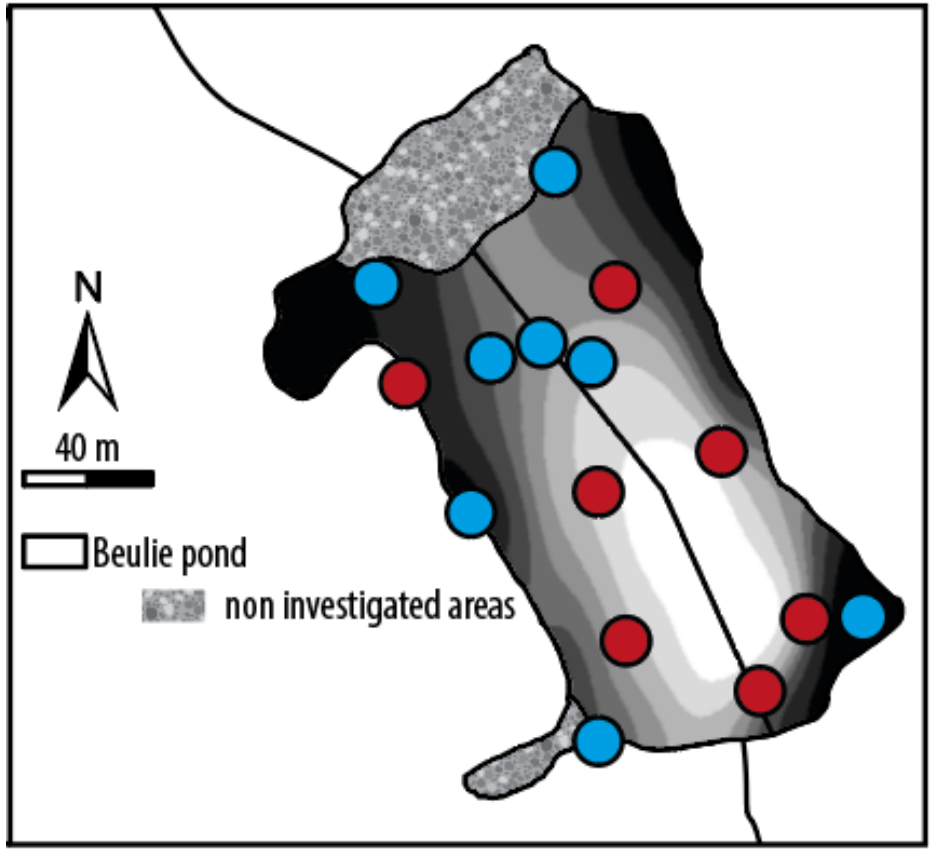
- Clays composition-> XRD

### Geochemical characterizations

- Total Organic Carbon content -> Rock-Eval pyrolysis
- Trace metals characterization and quantification -> ICP-MS
- Pharmaceutical molecules characterization and quantification -> LC-MS

## SPATIAL DISTRIBUTION ANALYSIS

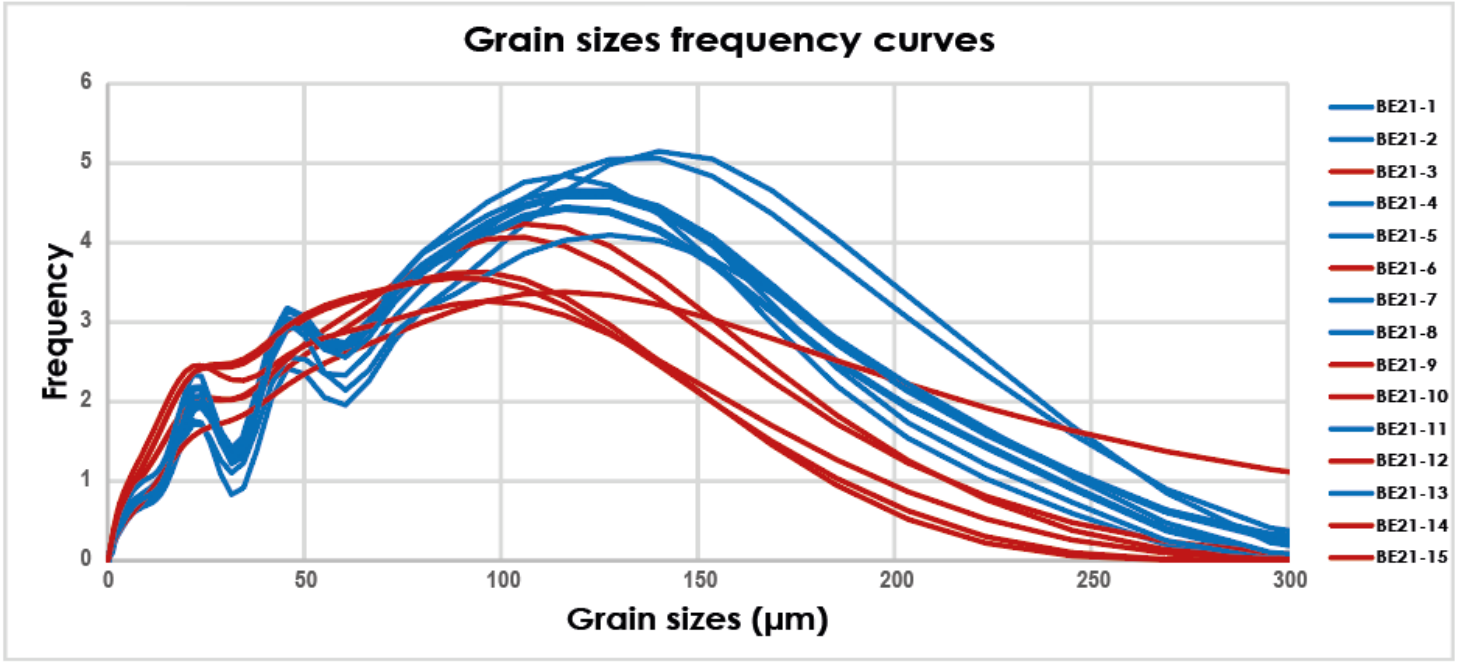
- Geographic information System




**Sedimentary dynamics of interface sediment samples within the Beulie pond (Bernier-Turpin 2022)**

Unsorted granulometry

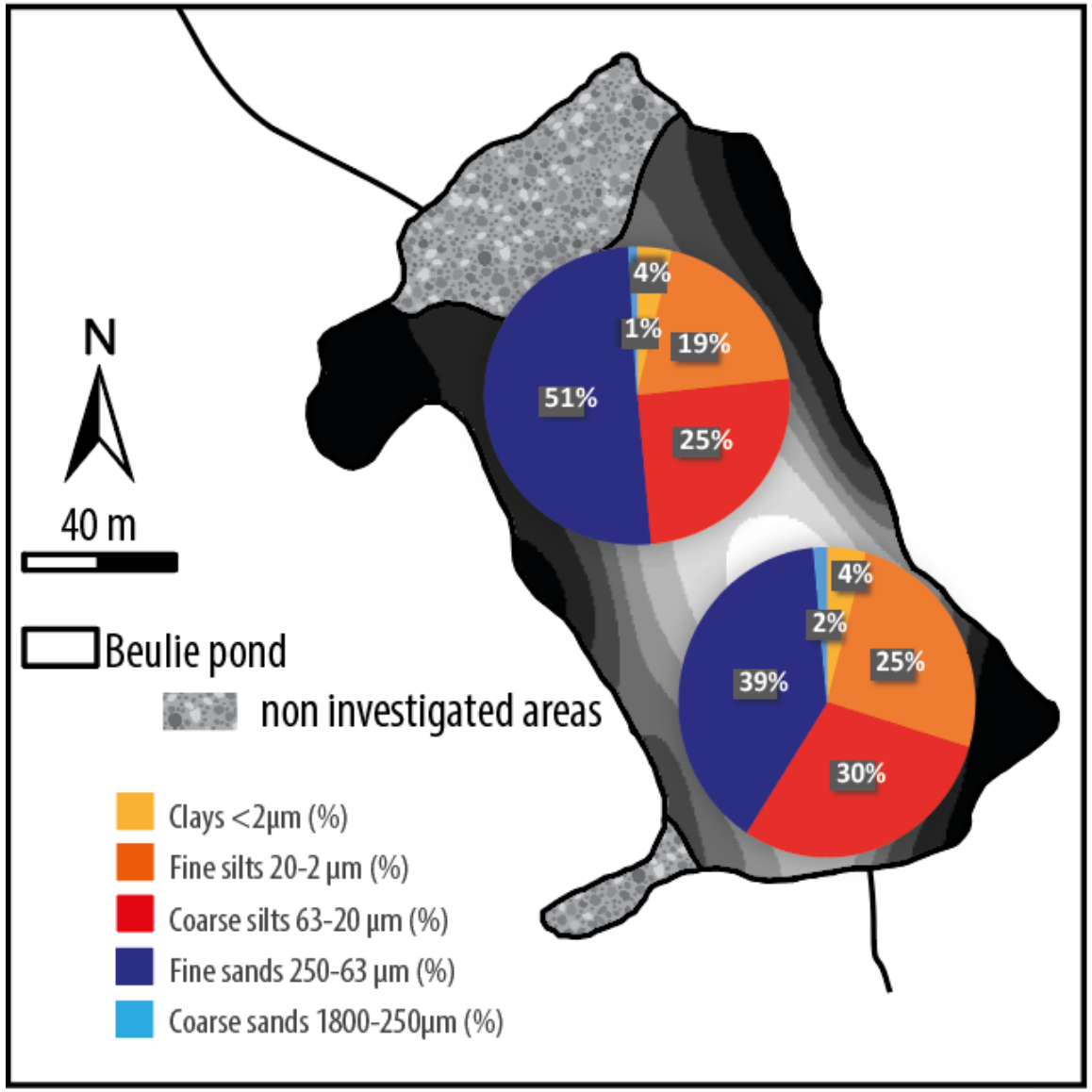
Sorted granulometry



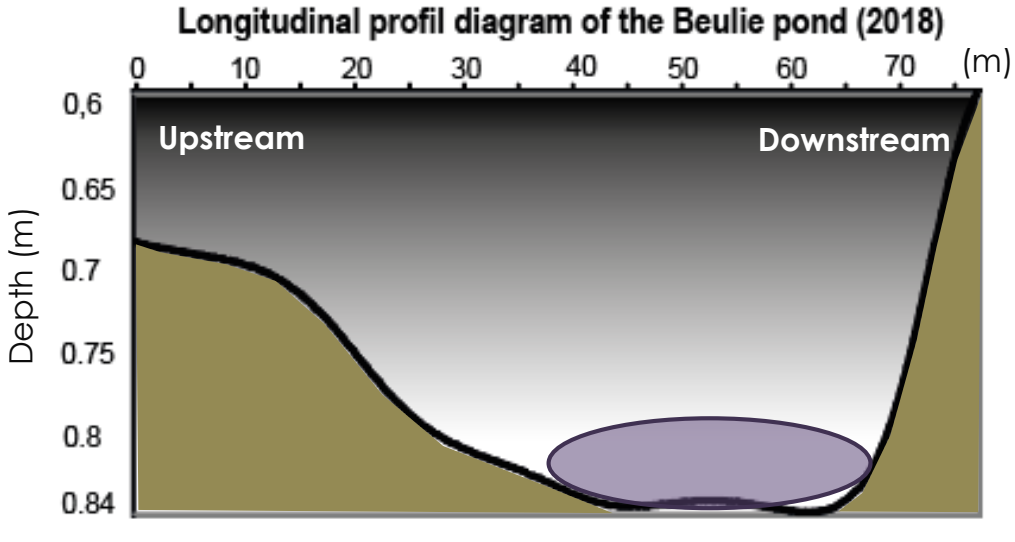

***Bernier-Turpin, 2022***

Grain sizes distribution : Upstream/Downstream cutting

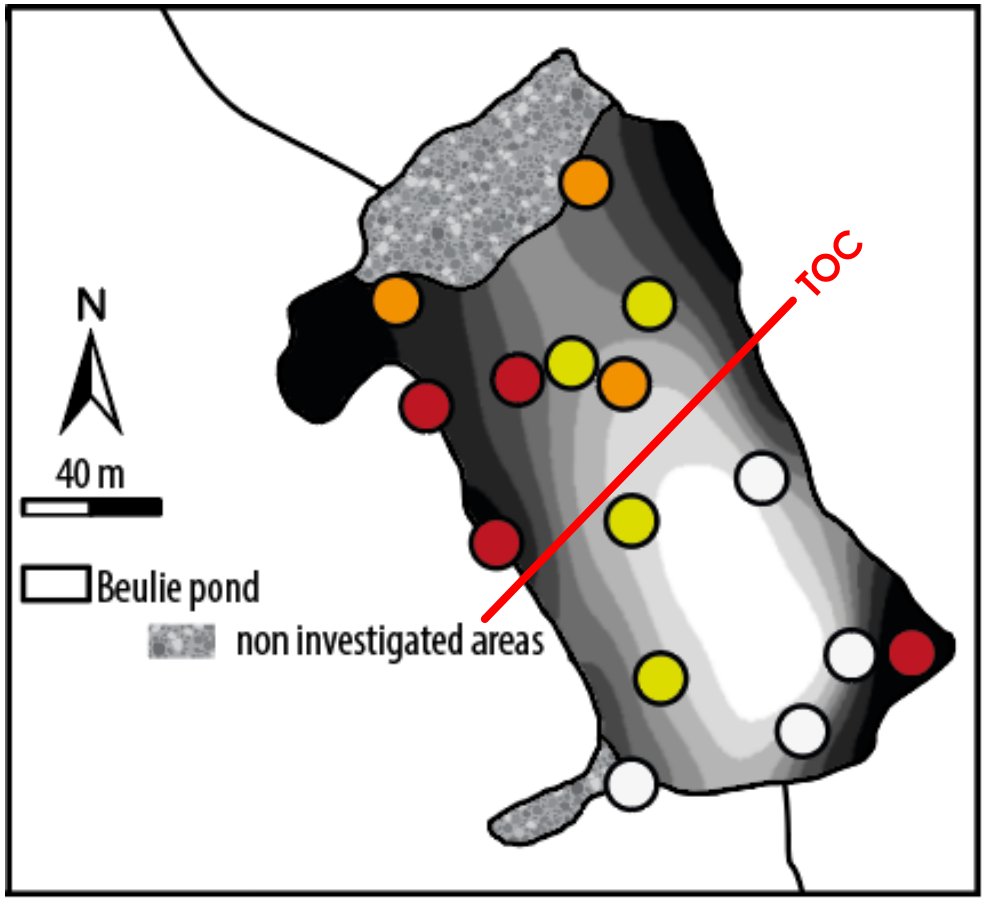
- Well sorted particles are concentrated mainly in the upstream part of the pond, and in shallower areas




Granulometric distribution : Fine particles more represented dowstream




- More fine particles are accumulating in the deeper areas of the pond -> granulometric sorting

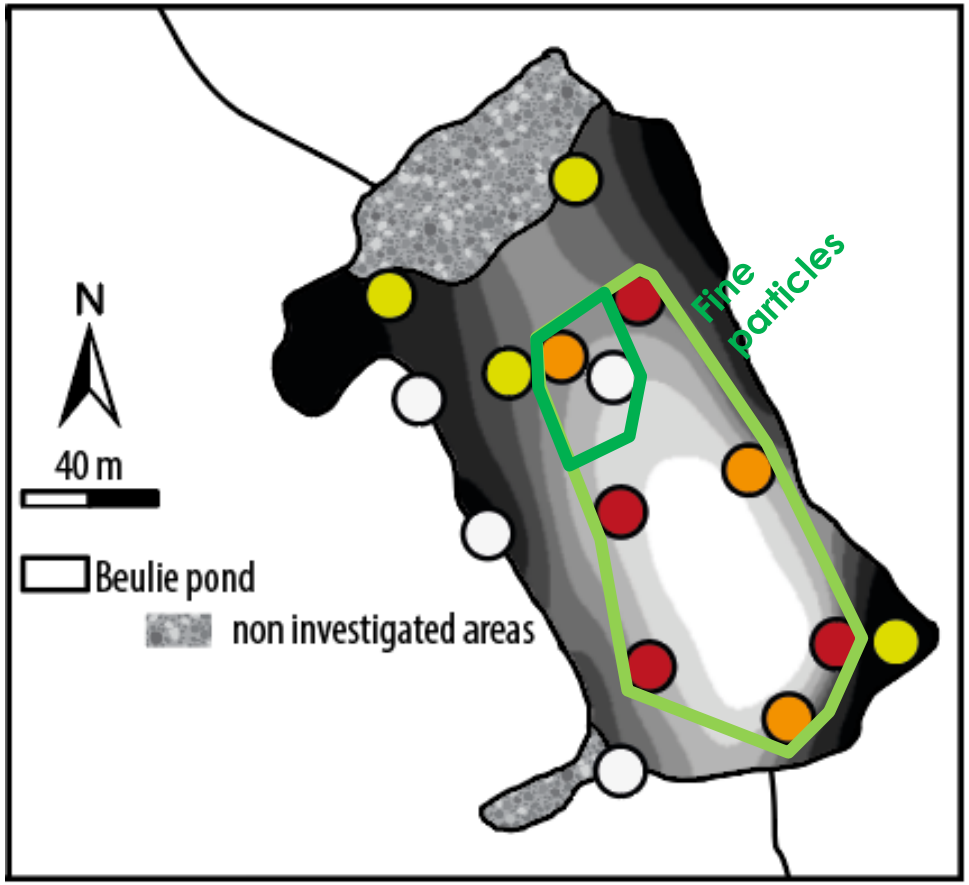



Beulie Total Organic Carbon distribution (%)

- 10.0 - 11.8
- 11.8 - 12.2
- 12.2 - 14.4
- 14.4 - 17.2

Total Organic Carbon (TOC) distribution : Upstream/Downstream cutting

- TOC concentrated in shallower areas
- Potential side effect -> accumulation of organic residues such as dead leaves

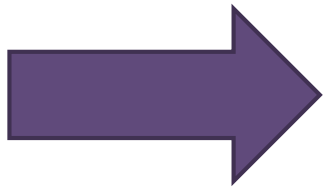



Beulie Fine Particles (< 63µm) distribution (%)

- 43.9 - 46.8
- 46.8 - 52.7
- 52.7 - 59.5
- 59.5 - 65.2

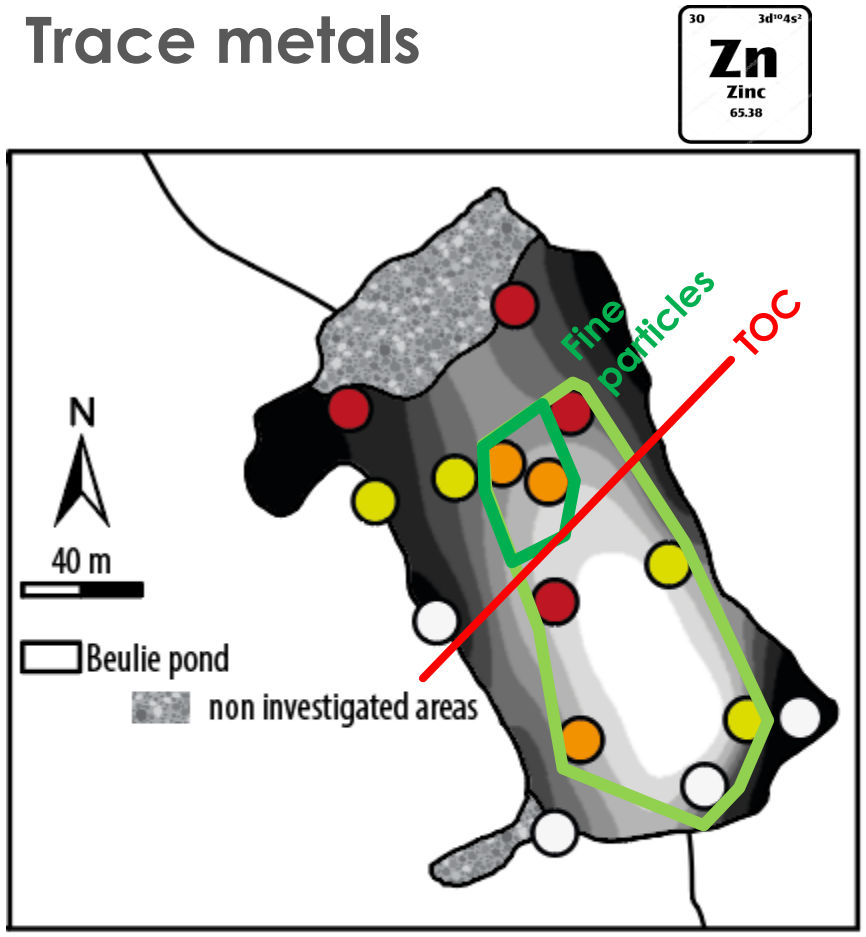
Fine particles distribution : cutting in the centered-downstream area of the pond

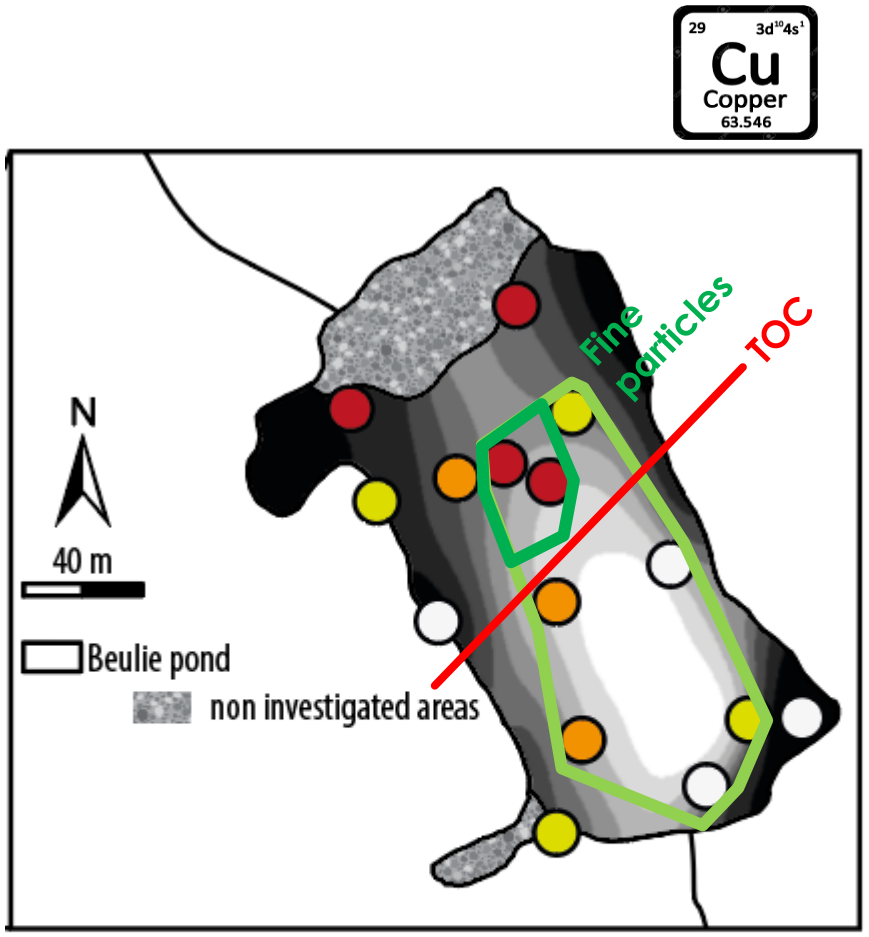
- Fine particles concentrated in deeper areas
- Those areas also correspond to the «unsorted granulometry »



And now what about the spatial response of inorganic and organic contaminants ?

# Trace metals




**Beulie Zinc distribution (µg/g)**

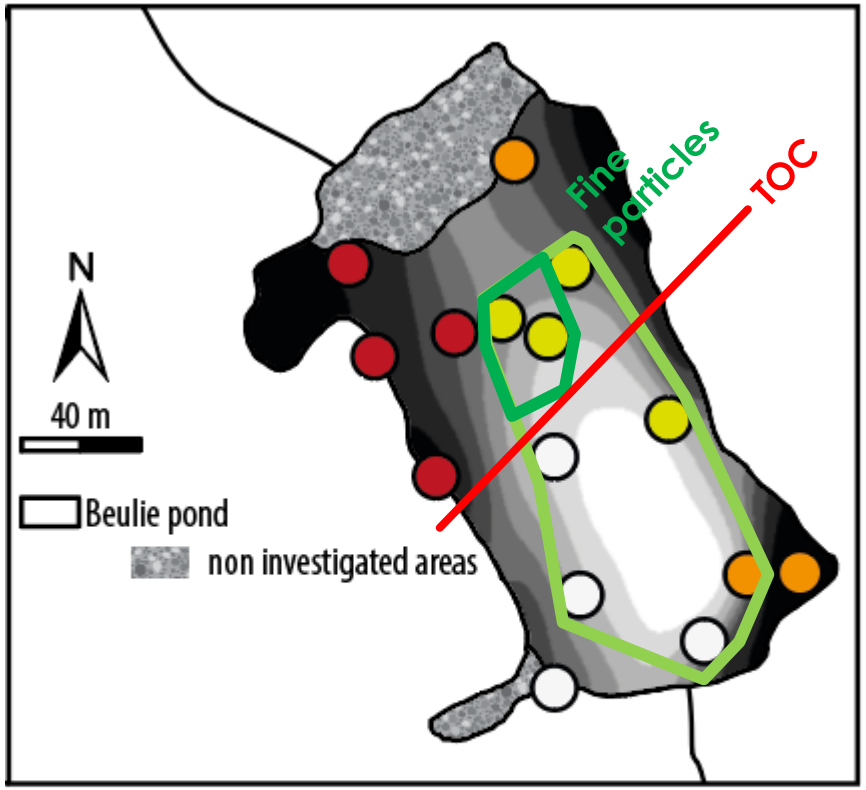
- 81 - 91
- 91 - 117
- 117 - 123
- 123 - 127

**Beulie Copper distribution (µg/g)**

- 757 - 850
- 850 - 1043
- 1043 - 1086
- 1086 - 1191

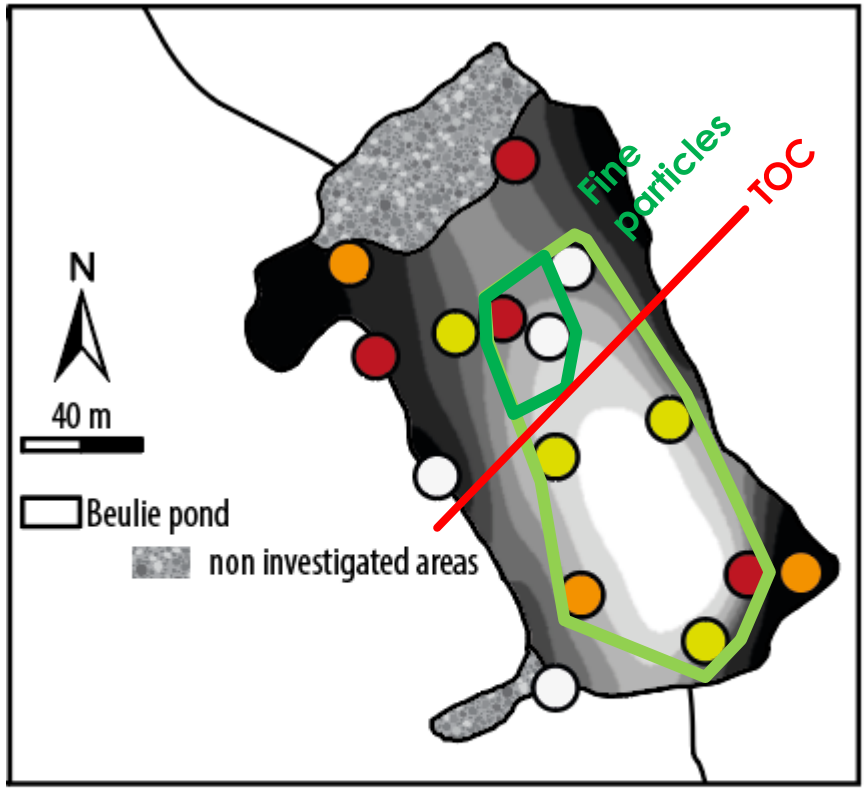
- The highest contents in Cu and Zn are concentrated mainly in the upstream part of the pond
- Without evident spatial distribution
- <u>Both might be carried by several phases, in different proportions</u>

# Pharmaceuticals




Beulie Total Neutral Pharmaceutical molecules distribution (ng/g)

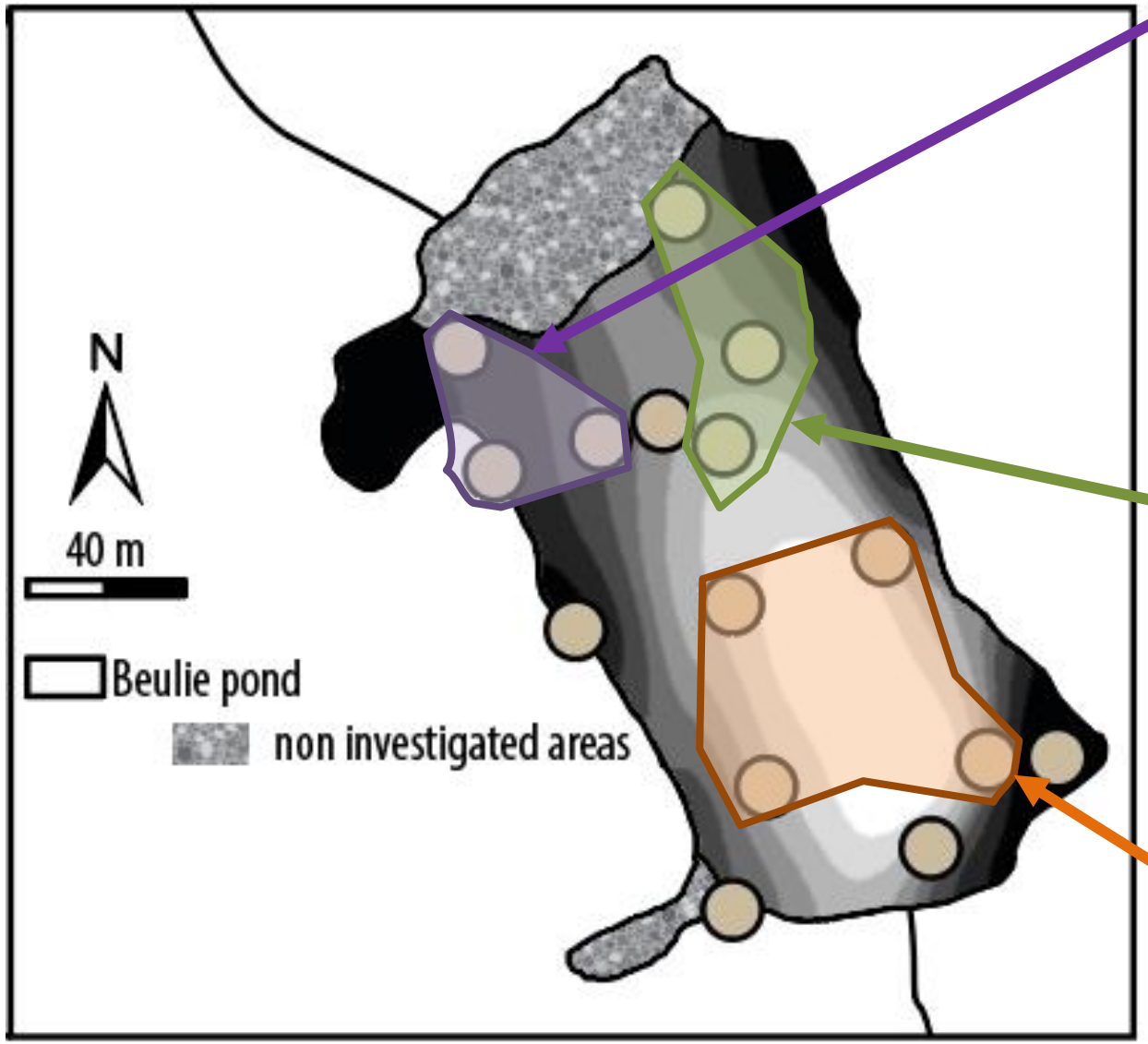
- 90 - 132
- 132 - 189
- 189 - 332
- 332 - 810




Beulie Total Cationic Pharmaceutical molecules distribution (ng/g)

- 1 - 9
- 9 - 11
- 11 - 17
- 17 - 39

- Areas with the highest contents are also the deeper
- Existing affinities between those molecules and reactive phases have to be identified




TOC = +++

= +

= +

TOC = +++

= ++

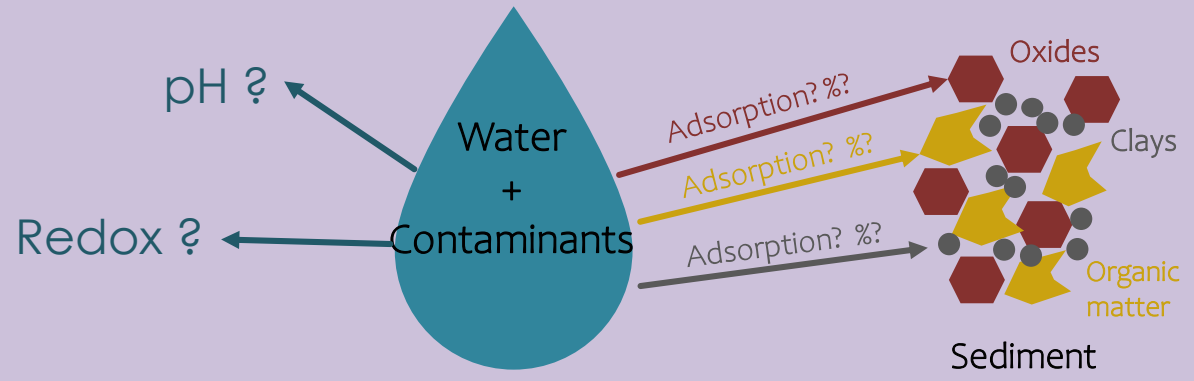
TOC = +

Fine particles = ++

cationic

= +++

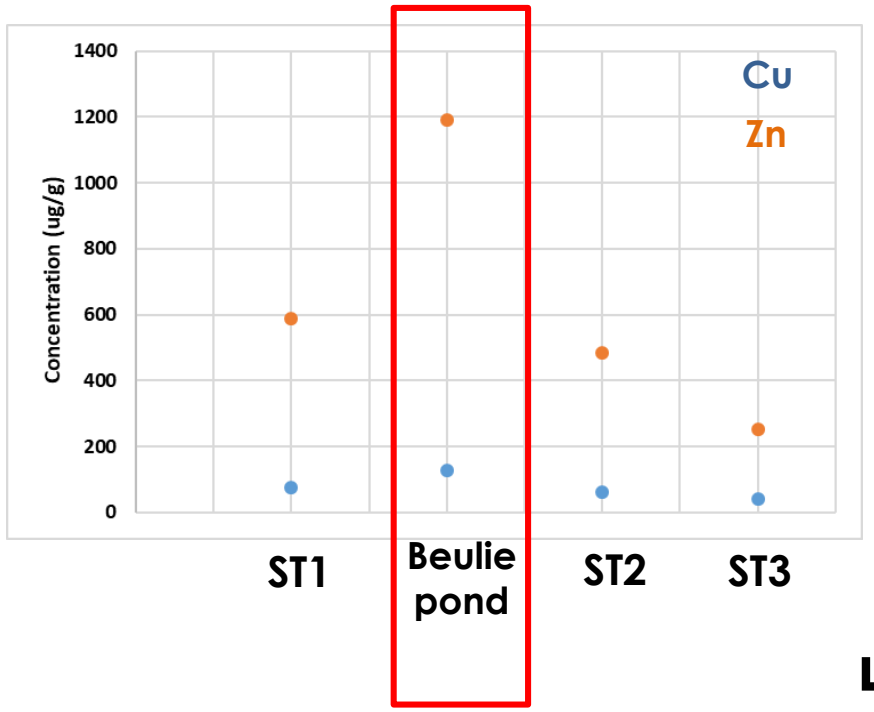
- Heterogeneous spatial distribution of anthropogenic contaminants at the pond scale
  - The spatial distribution of the matrices (TOC, Fine particles) doesn't clearly explain those of anthropogenic contaminants
  - 15 samples here -> more have been collected and can be characterized as well
- Both carrying phases, molecules/trace metals, and medium properties have to be taken into acount in adsorption mechanisms

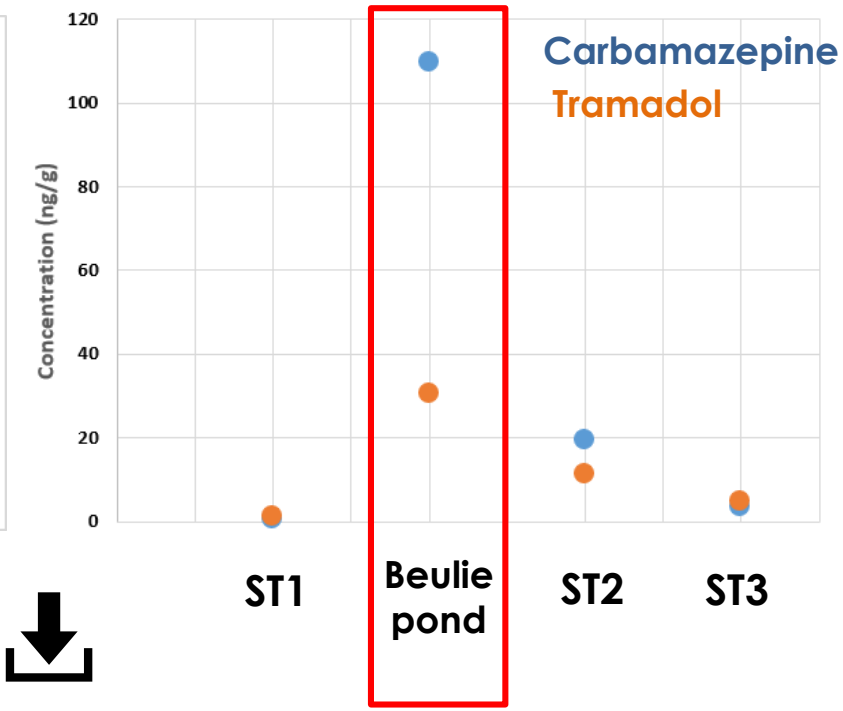


## Comprehension of spatial distribution is a real concern…

**Concentrations measured in the particulate phase, 2021**

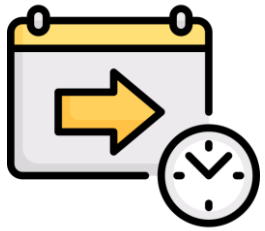
*Bernier-Turpin, 2022*



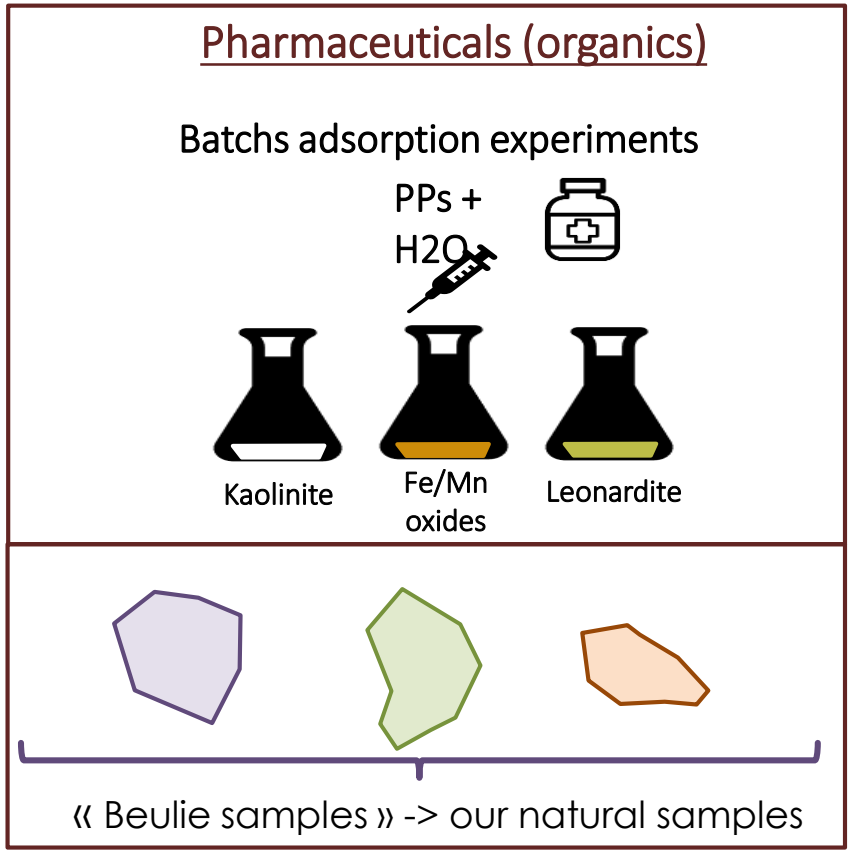

**Beulie pond -> stock, but contaminants are crossing the pond's barrier…**

## … as well as comprehension of mechanisms



**Ongoing experiments …**

- Identification and quantification of sediment's compartments
- Determination of adsorption mechanisms




Batchs experiments on pure equivalent matrices

Batchs using our natural samples

**PARTICULATE** — **AQUEOUS**

**Sediment/Colloids/Water Continuum**

**THANK YOU FOR YOUR ATTENTION**

Thanks to Gauthier Bernier-Turpin, Thomas Thiebault, Gildas Ratié, Nicolas Freslon, Claude Le Milbeau, Rachel Boscardin and Marielle Hatton for their help and implication in this work

**ANY QUESTIONS ?**