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Institut Pluridisciplinaire Hubert CURIEN STRASBOURG

LIFE CYCLE ASSESMENT OF TRITIUM IN THE SYSTEM OF THE GRAND CANAL D'ALSACE AND RHINE RIVER

Internship period : 18 February 2019 -18 July 2019

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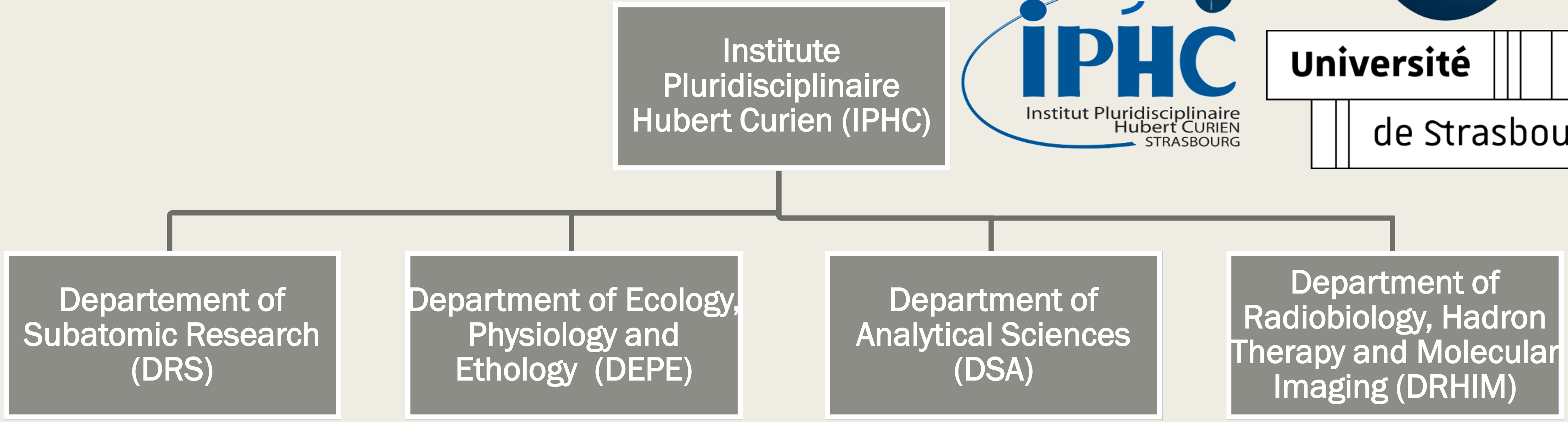
INSTITUTE PROFILE



Research Field :

- Nuclear physics and particle physics.
- **Radiochemistry.** → Internship Research Group
- Radiation protection.

INTERNSHIP MAIN OBJECTIVE

To calculate a fate factor of Tritium in the system of Rhine river and Grand Canal Alsaces in order to model transfer mechanisms between water and sediments.

INTERNSHIP SPECIFIC OBJECTIVES

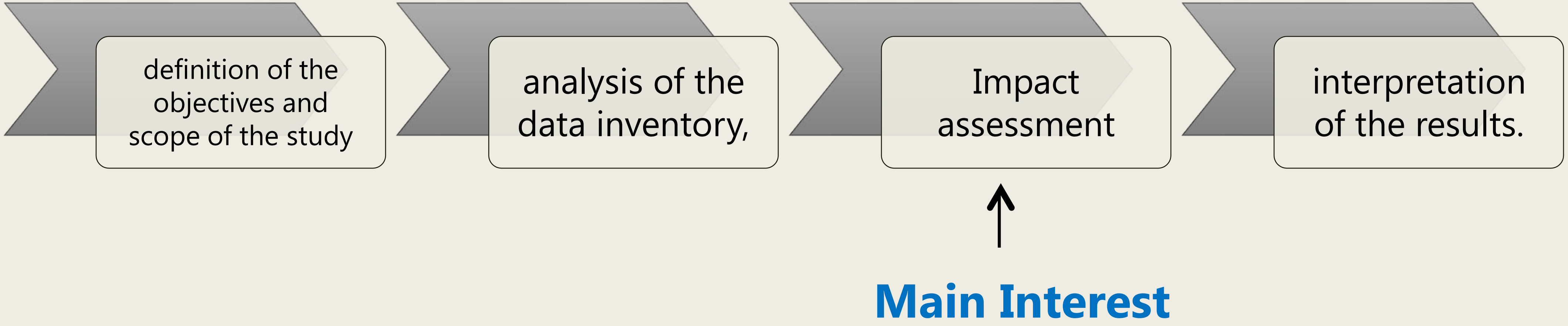
- Analysis of waters in the Rhine and Grand Canal Alsace systems.
- Analysis of nanoparticles
- Experiments on sediment collected in the Rhine river

SUMMARY

INTRODUCTION

LIFE CYCLE ASSESMENT

- Life Cycle Assesment (LCA) is a standarized tool for assessing the environmental impacts of elements in a system.



LIFE CYCLE ASSESEMENT

To calculate the pollutant transfer in the environment, it can be charaterize by using mathematical equation :

$$CF = FF \times EF$$

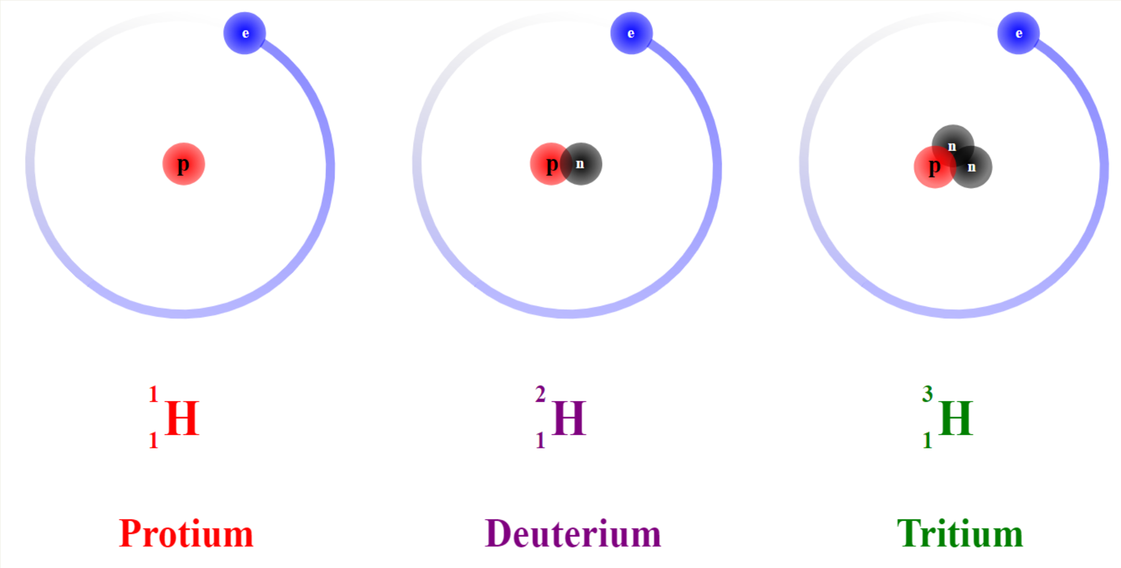
characterization factor

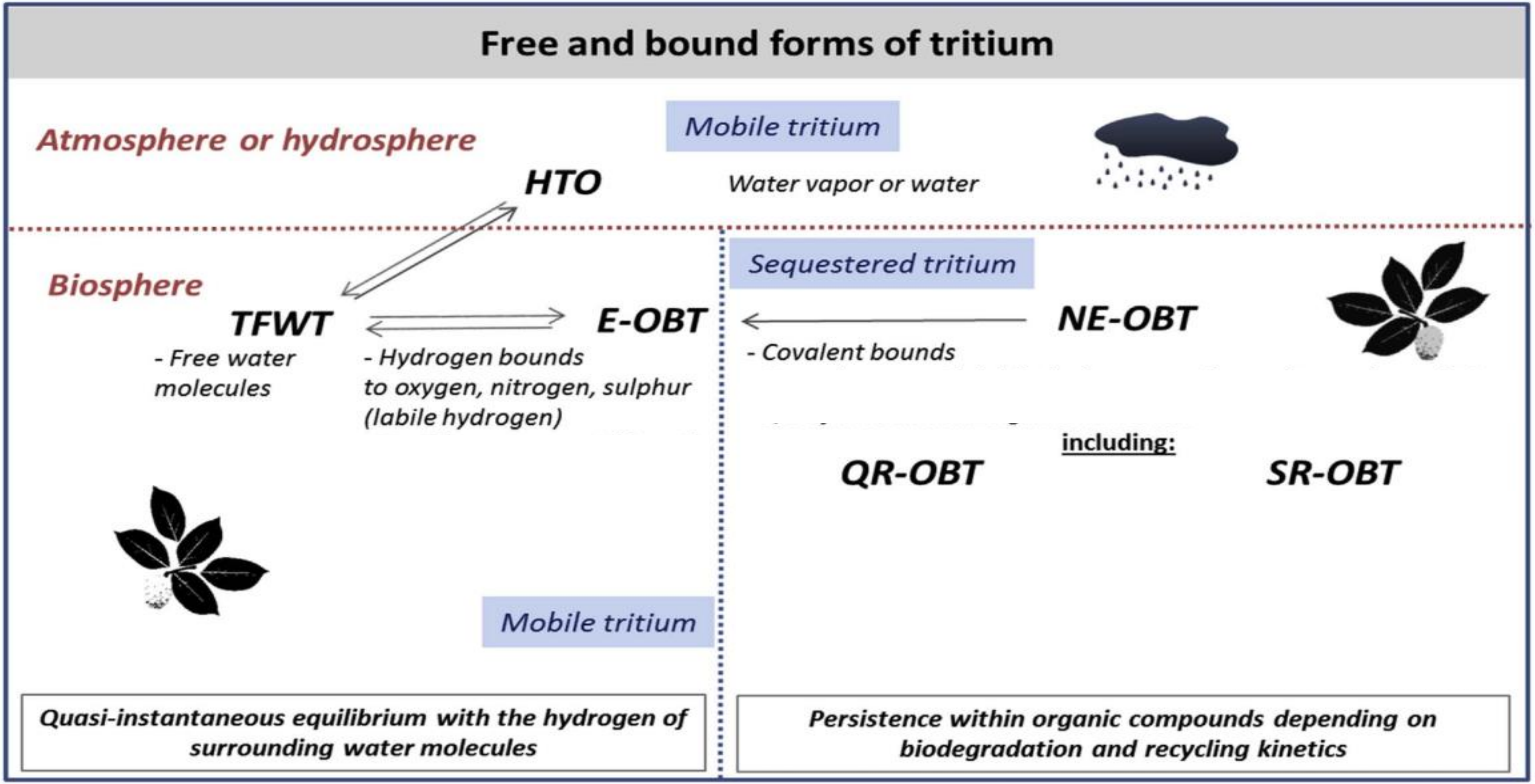
Fate factor

Effect Factor

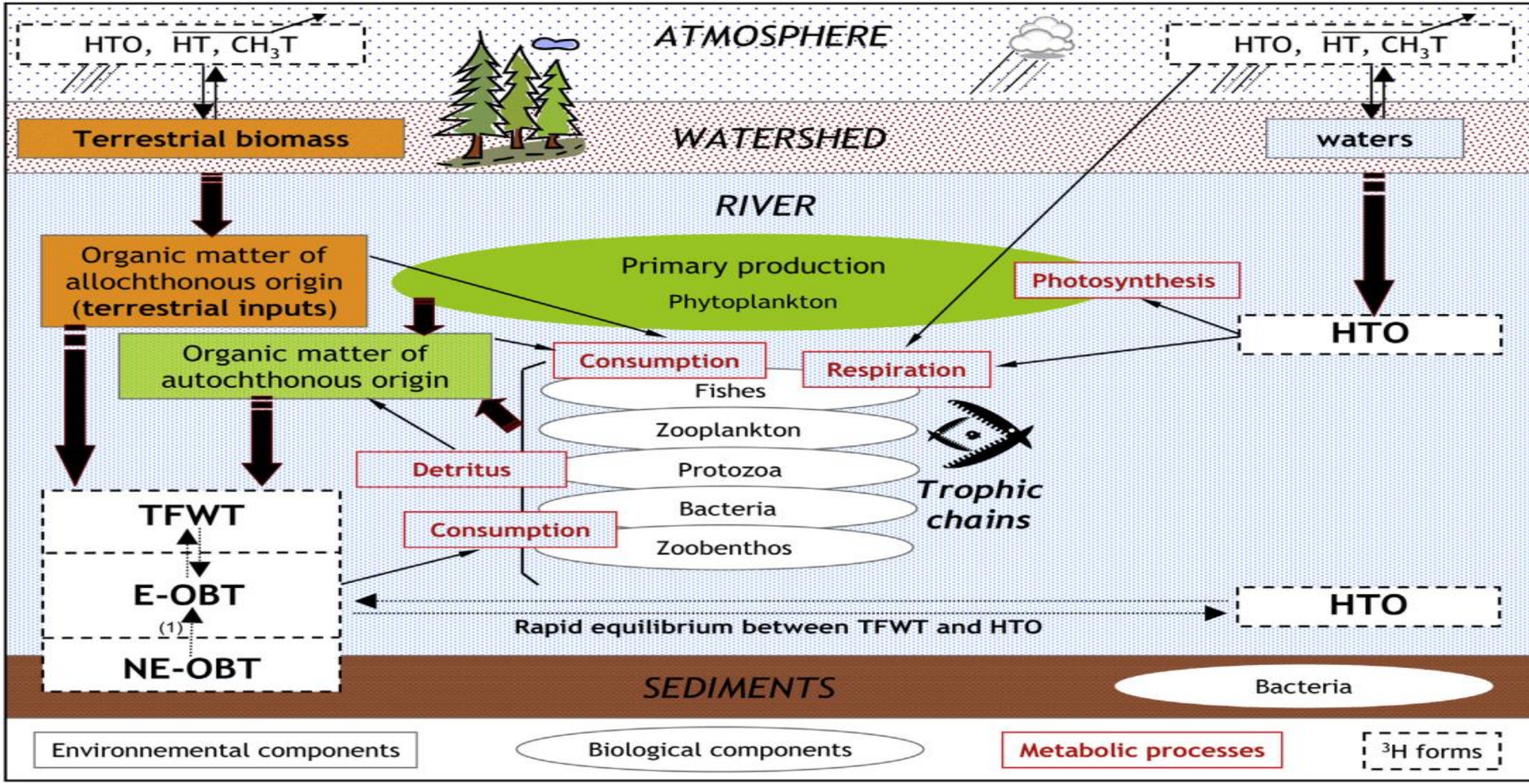
WHAT IS TRITIUM ?

- Tritium (^3H) is heavy isotope of hydrogren. It is pure beta emitter with energy 18.3 keV and it has half-life 12.3 years.
- Tritium production :
  - *from nature, it called cosmogenic tritium.*
  - ***Nuclear Power Plant** and **Chemical Industry**.*





Eyrolle, F., Ducros, L., Dizès, S.L., Beaugelin-seiller, K., Charmasson, S., Boyer, P., Cossonnet, C., 2018a. An updated review on tritium in the environment. J. Environ. Radioact. 181, 128–137. https://doi.org/10.1016/j.jenvrad.2017.11.001



- Cossonnet, C., 2014. Apparent enrichment of organically bound tritium in rivers explained by the heritage of our past 136, 162–168. https://doi.org/10.1016/j.jenvrad.2014.05.019

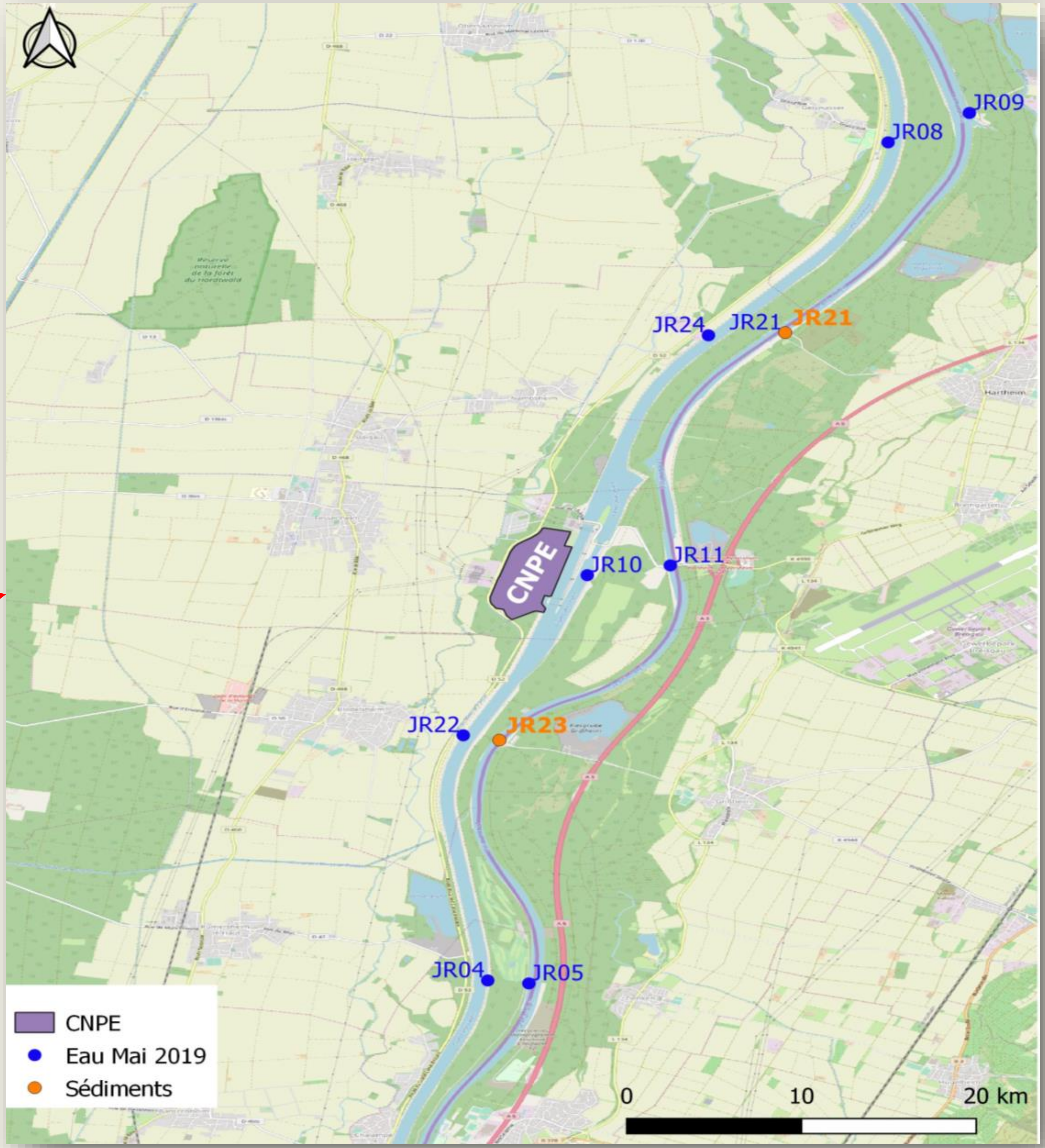
WHY WE STUDY TRITIUM?

1. Tritium behaviour in aquatic environment **still not well known.**
2. OBT depends on interaction with **organic matter and** possibly **nanoparticles in river.**
3. OBT can be accumulated in living organism, which is can make **ecotoxicity.**
4. To know characterization factor of tritium, we need study what parameters that can **contribute to fate factor**.
5. There are **no study has been done** related to tritium analysis in the Rhine River System.

MATERIALS AND METHODS

STUDY AREA


Belgium
Cologne
Germany
English Channel
Frankfurt
Luxembourg
Paris
Fessenheim NPP
France
Bern
Switzerland
Alps
Biscay
Milan
Turin
Marseille
446 km
Image Landsat / Copernicus
© 2018 Google
© 2009 GeoBasis-DE/BKG
US Dept of State Geographer


JR09
JR08
JR24
JR21
JR21
CNPE
JR10
JR11
JR22
JR23
JR04
JR05
CNPE
Eau Mai 2019
Sédiments
0
10
20 km

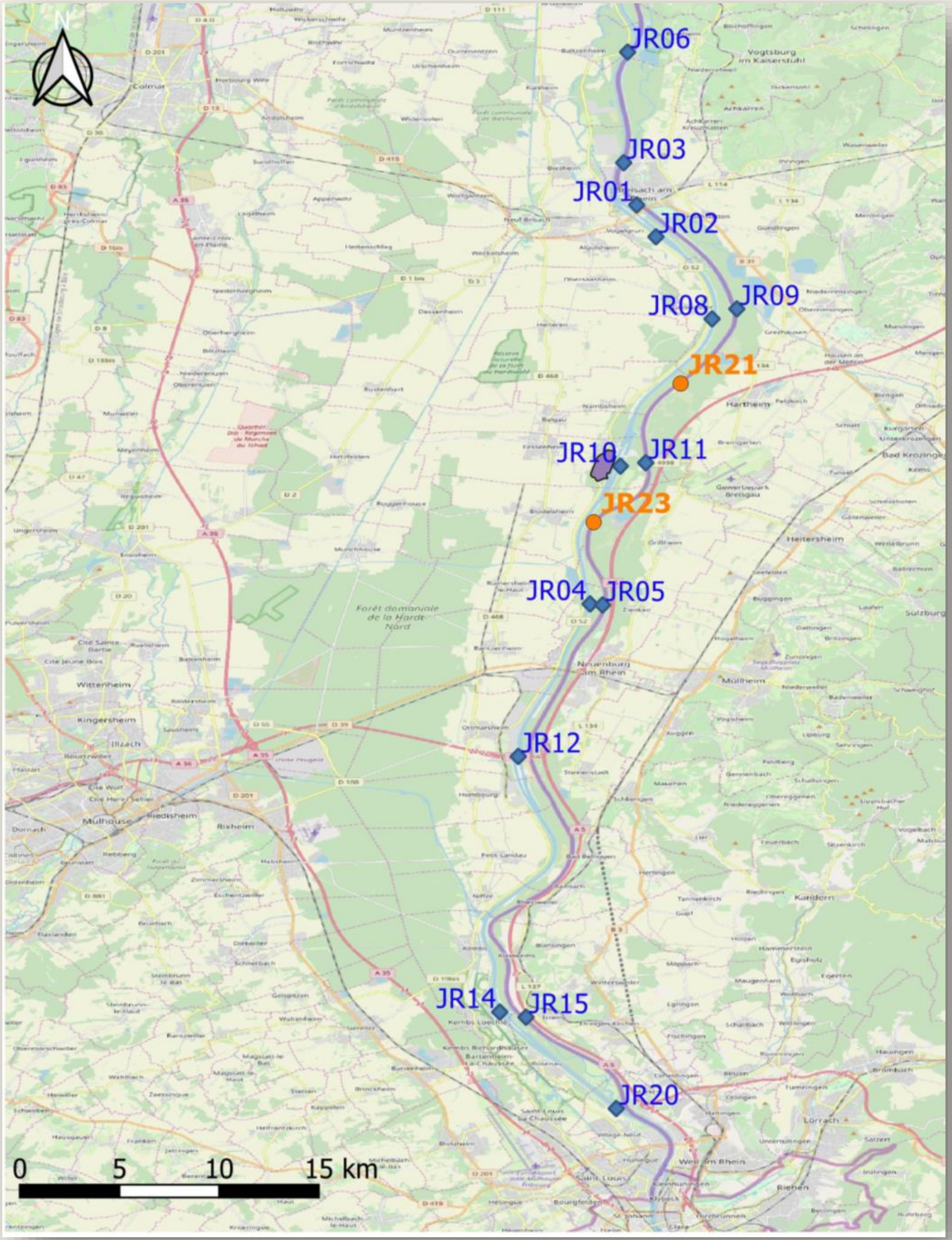
FESSENHEIM NPP

- PWR Type Reactor
- Has 2 Reactors that produced 900 Mwe for each reactor
- Has been operated since 1 January 1978
- Used **GCA for cooling system**
- Releases 0.71 GBq/year tritium in gaseous form and 11.6 GBq/year tritium in liquid form (EDF, 2017; IAEA, 2007)
- Will be decommisioning in a few years


Photo by Ari SAPUTRA

STUDY AREA

- 3 sampling points in Rhine River
- 6 sampling points in Old Rhine,
- 6 sampling points in Grand Canal.
- The samples were taken during two different months: the first campaign was in March, and the second campaign was in May



Sample Processing : Water Chemistry

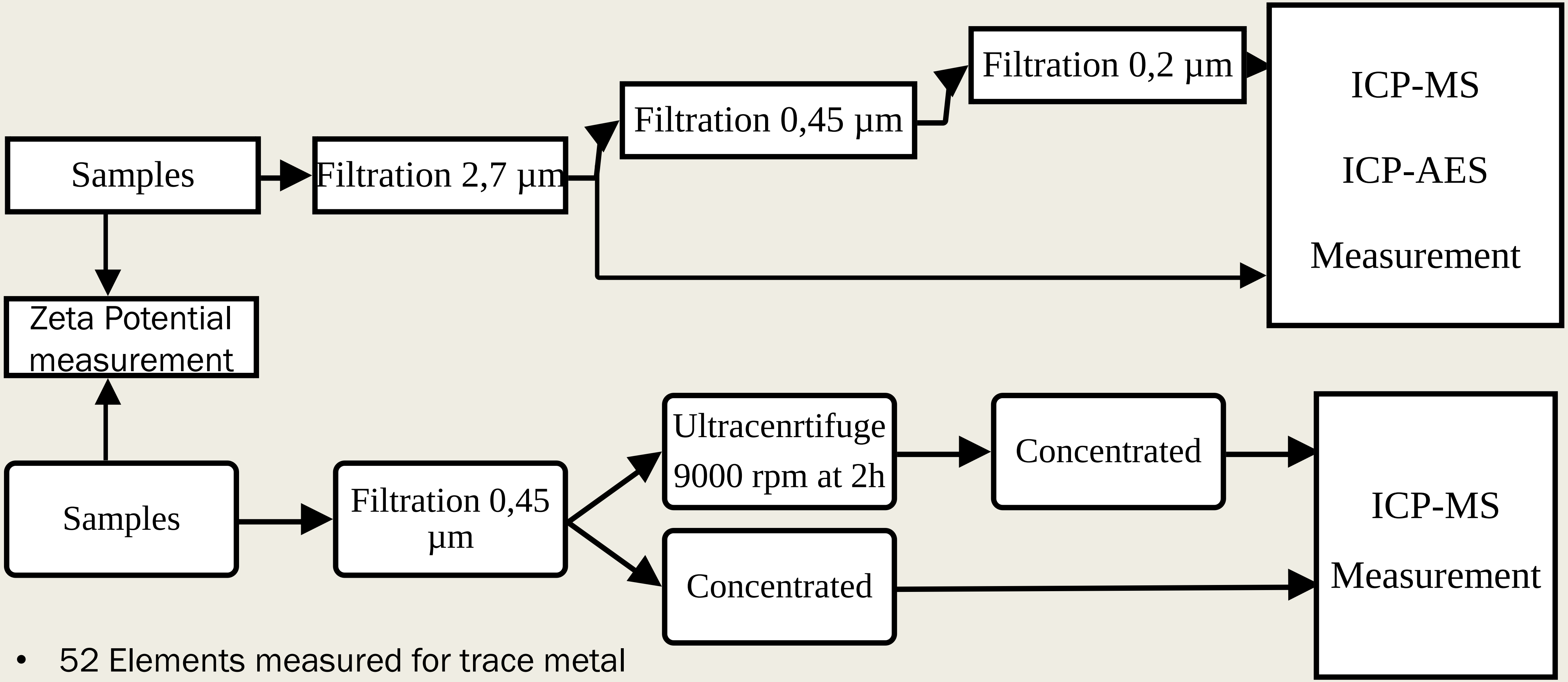
On-site Measurement

- pH
- Conductivity
- Dissolved Oxygen
- Temperature

In-lab Measurement

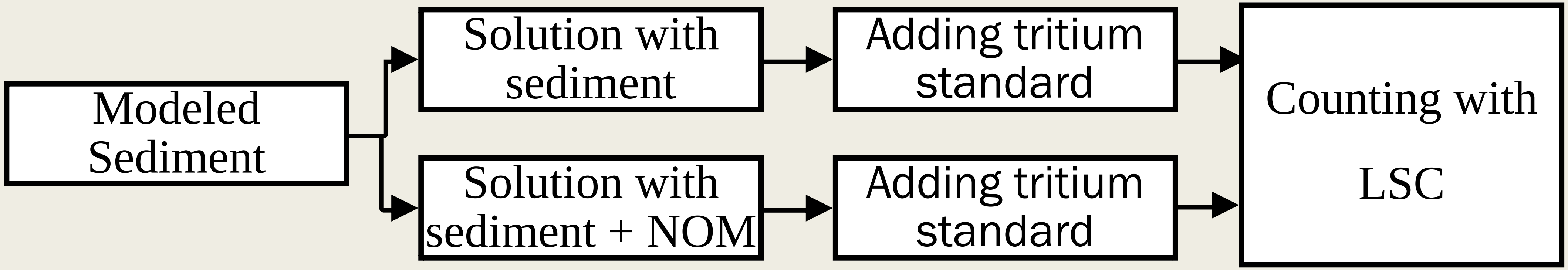
- Total organic carbon
- Zeta Potential
- Major Elements
- Trace Metal Elements
- Anions
- Tritium

Sample Processing : Nanoparticles



- 52 Elements measured for trace metal measurement

Sample Processing : Sediment Experiment

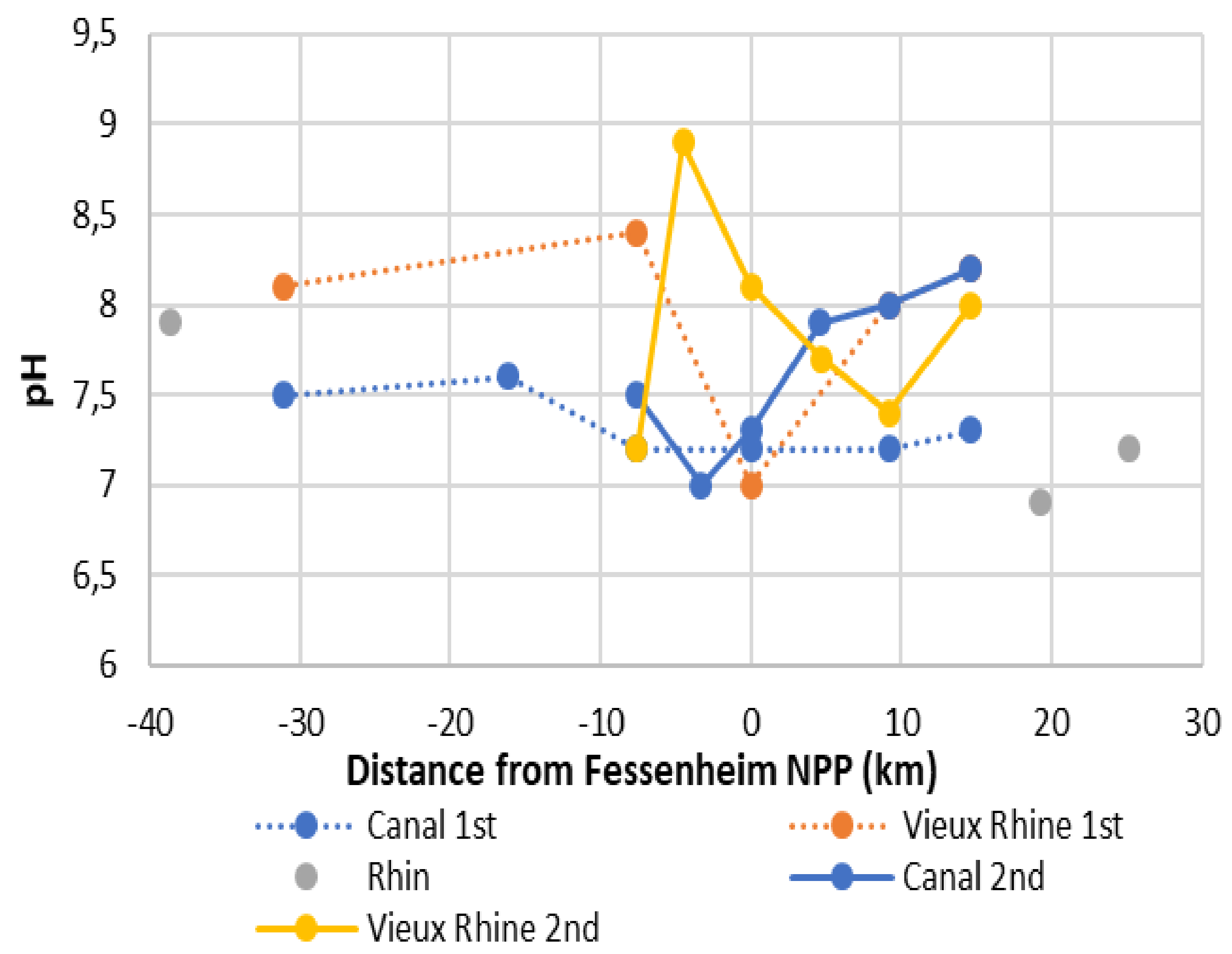


- The organic matter was collected in old Rhine (extracted and reconcentrated).
- Tritium standar → 10 µL , Activities = 74.1 Bq/L
- Ratio of sediment and organin matter = 0.2 mgC/L

WATER CHEMISTRY

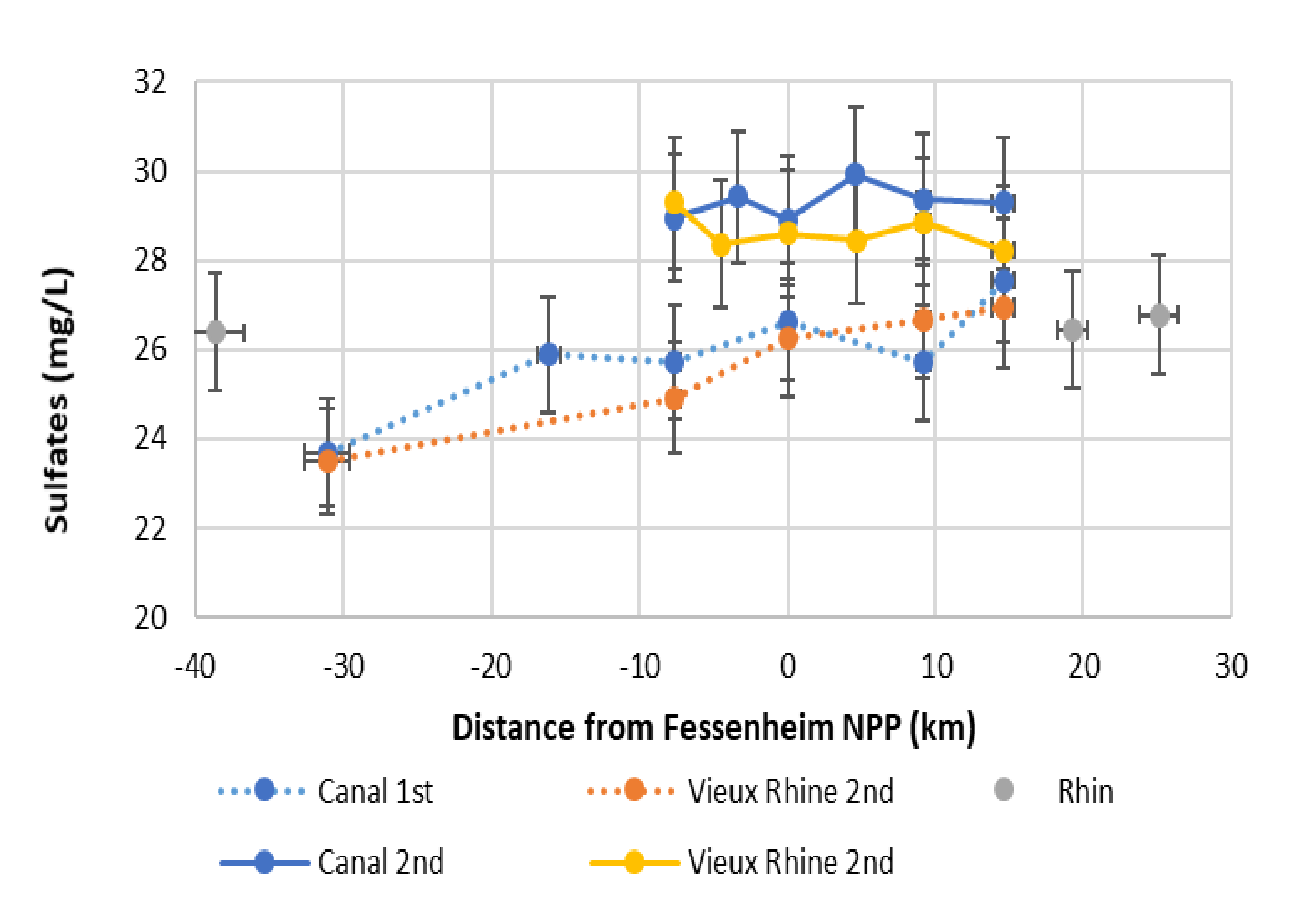
pH MEASUREMENT

- pH varies in the both system
- There is a possibility of a connection or exchange between the GCA and Rhine river
- pH range on both systems are 7 – 8,5
- Temperature does not vary



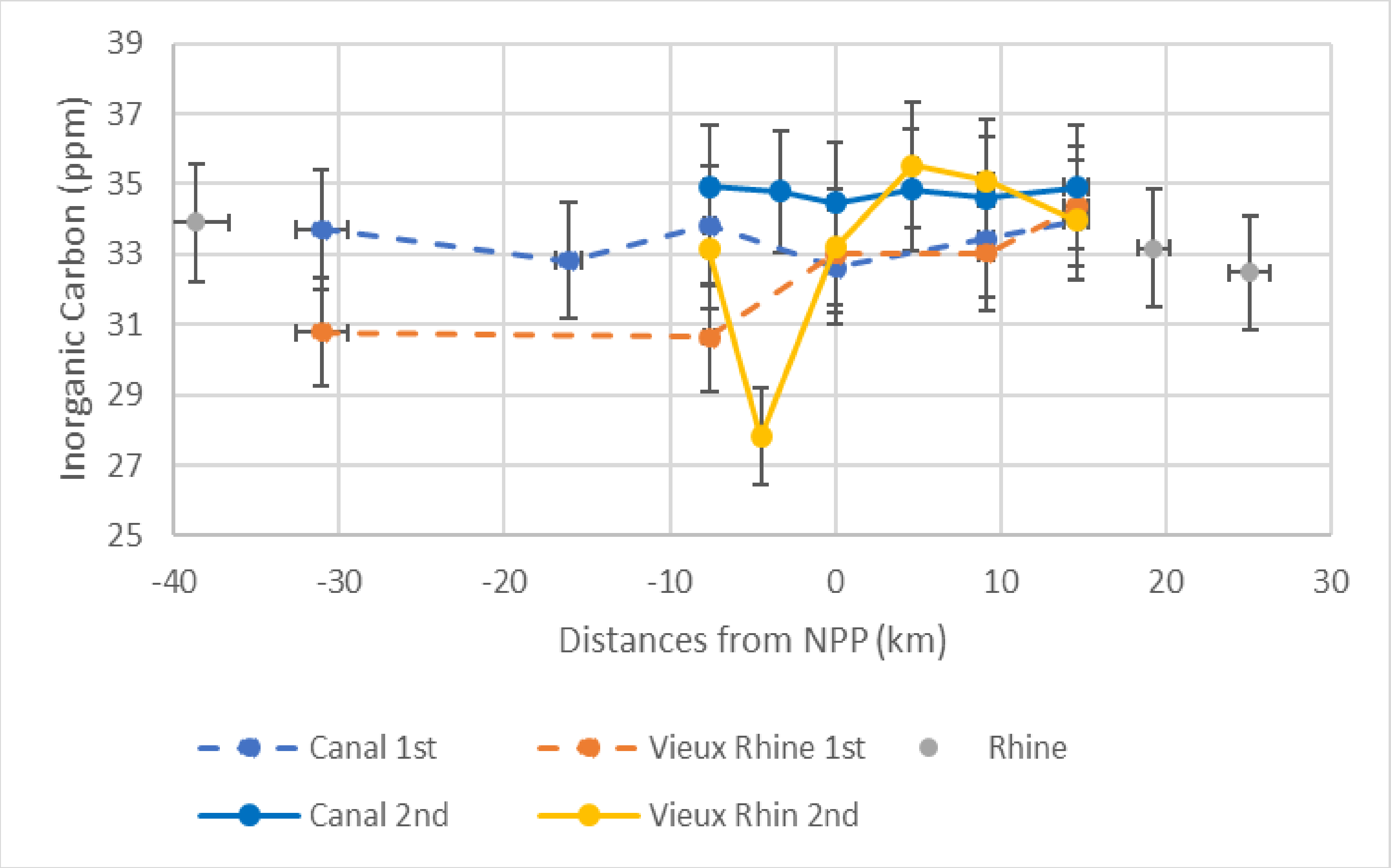
ANIONS MEASUREMENT

- Major Anions : sulfates and chlorine
- The evolution of major anions in both system are the same
- Anions is more concentrate in Old Rhine



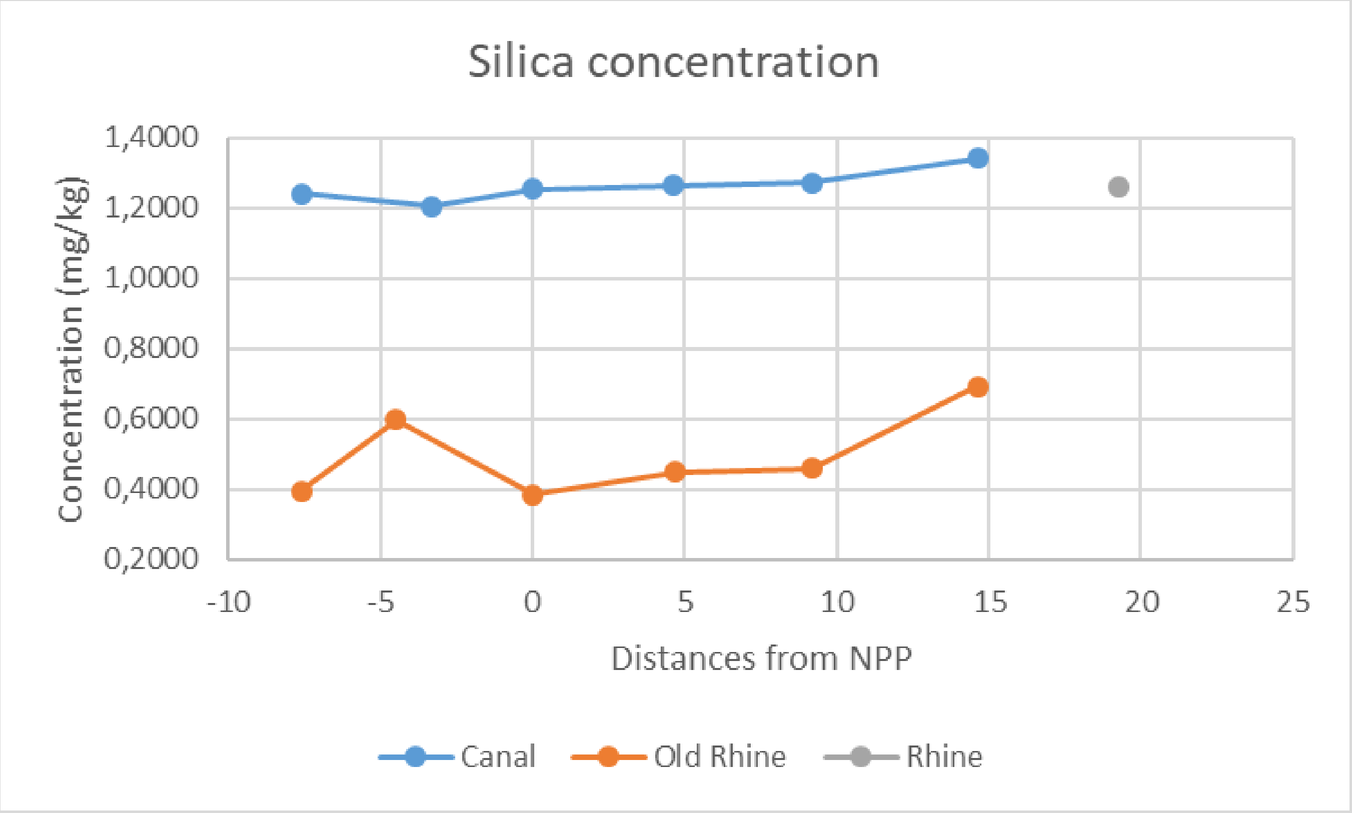
INORGANIC CARBON MEASUREMENT

- The concentration is the same from upstream to downstream.
- Both system have similar inorganic concentration
- Both system are highly carbonated water.



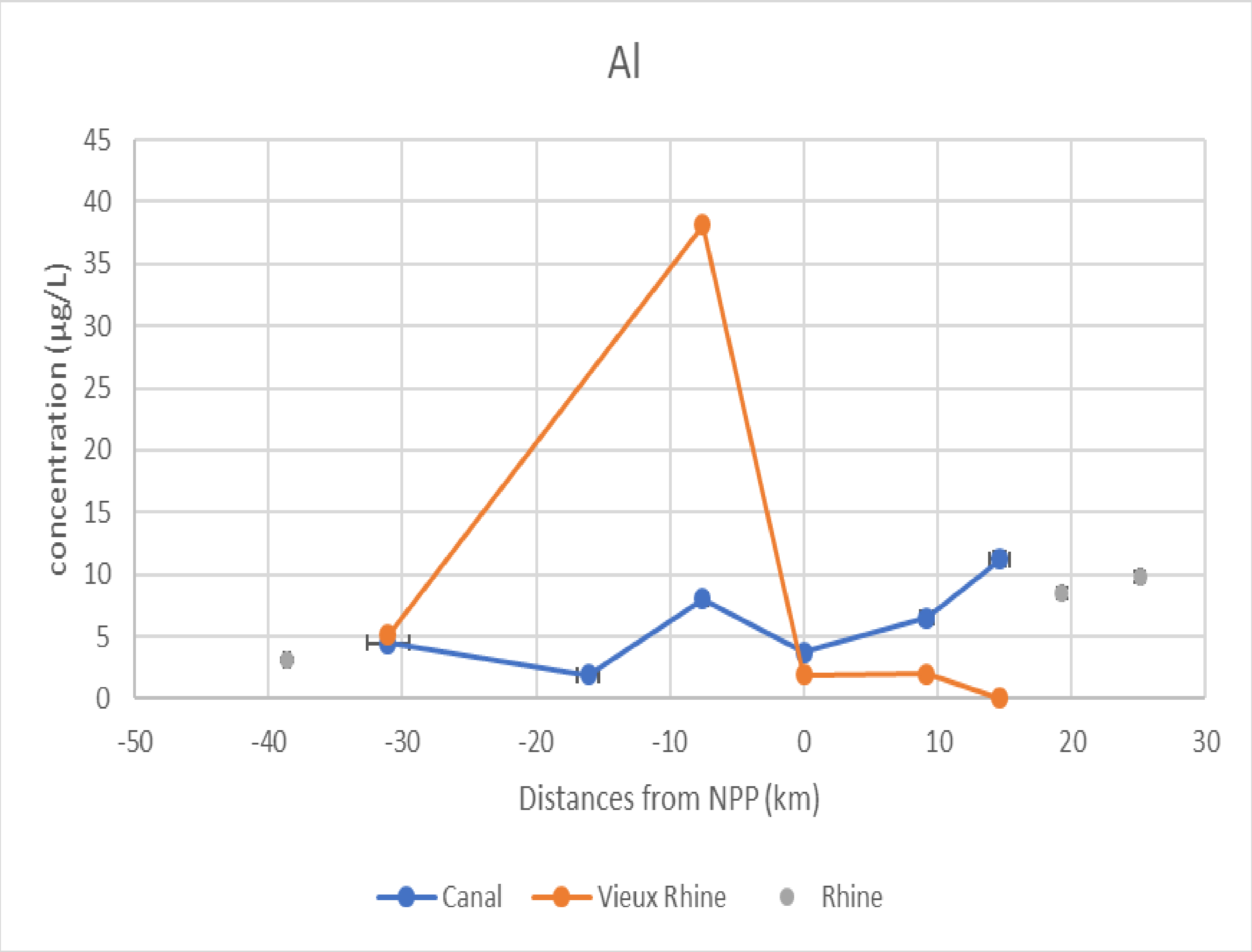
MAJOR ELEMENT CONCENTRATION

- Both systems have the similar evolution of major elements concentration (Al and Si).
- Si concentration is higher in the Grand Canal, as for the aluminum, the concentration is not different.



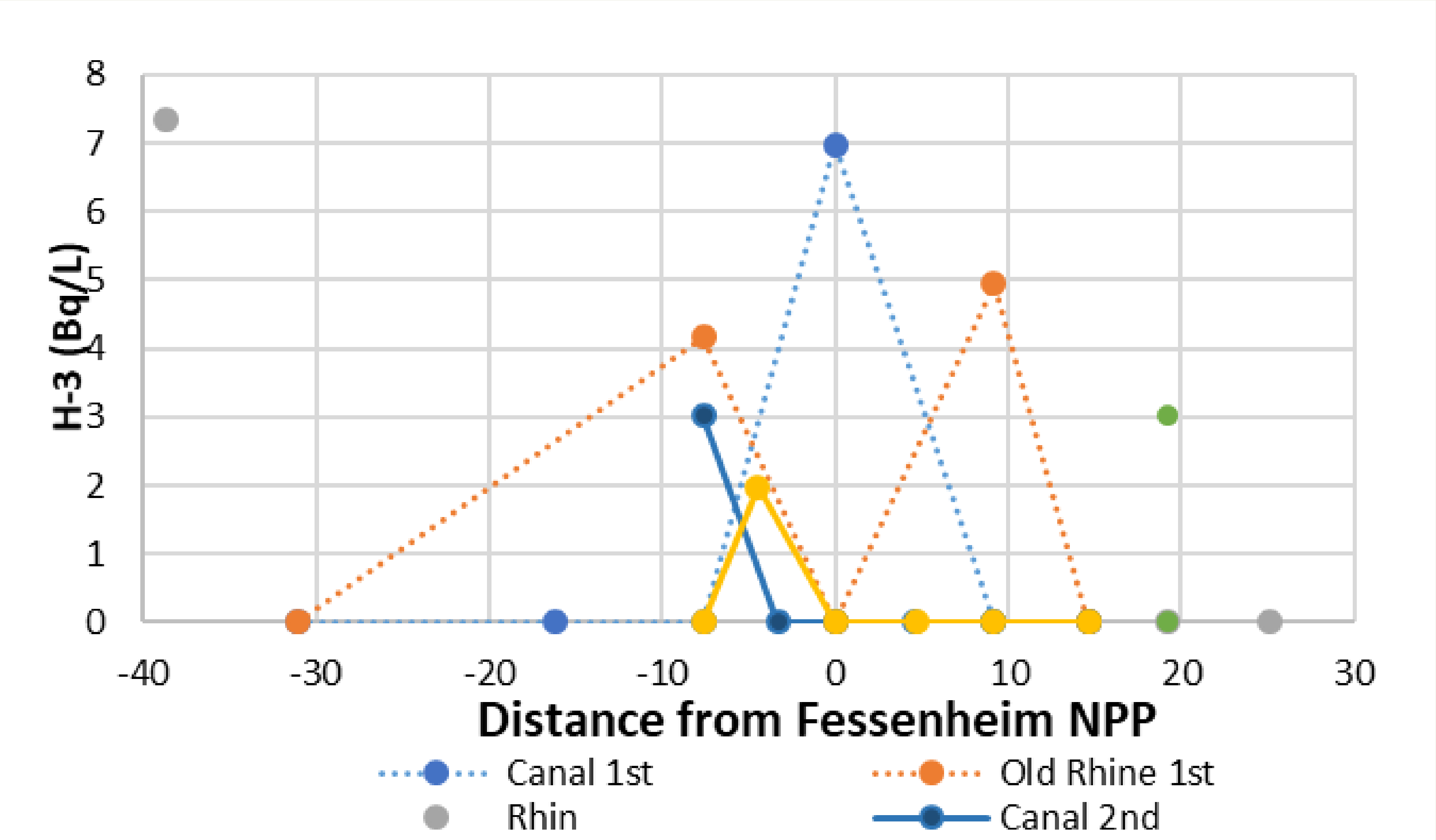
MAJOR ELEMENT CONCENTRATION

- Aluminum concentration is higher in old Rhine before the NPP, and the concentration decreases significantly.
- After the NPP, aluminum concentration in the old Rhine is lower than the aluminum concentration in GCA.



TRITIUM MEASUREMENT

- Tritium concentration is dynamic in both systems.
- Tritium can be found near the Fessenheim NPP.
- Other sources of tritium.



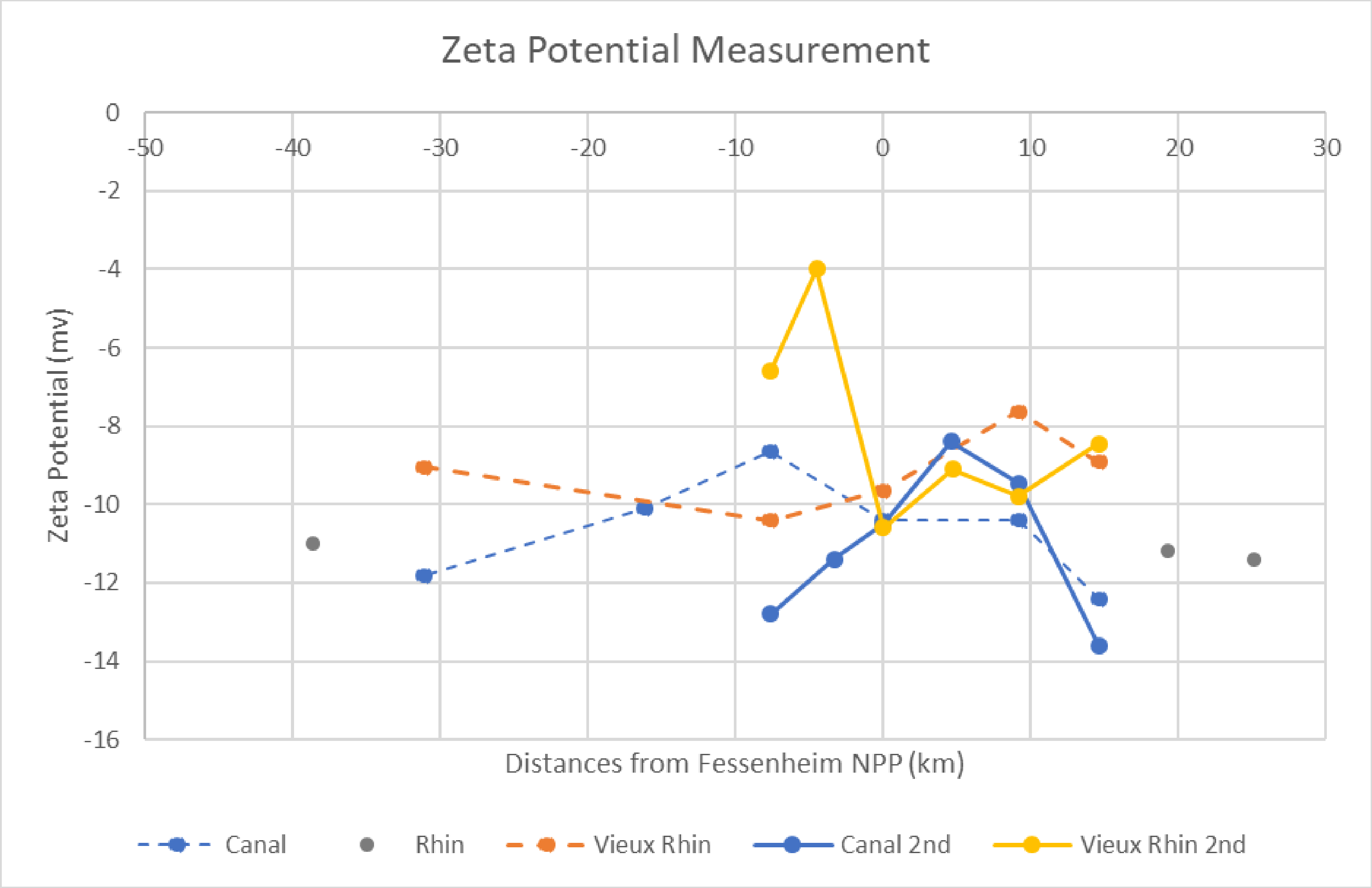
WHAT WE LEARNED FROM WATER CHEMISTRY

- pH shows that there is a possibility that GCA and old Rhine communicate or have an exchange near the NPP.
- Both system are carbonated water.
- The same evolution of :
  - Anions
  - Trace Metal
  - Major Elements
- The tritium concentration is varies along the old Rhine and GCA

NANOPARTICLES

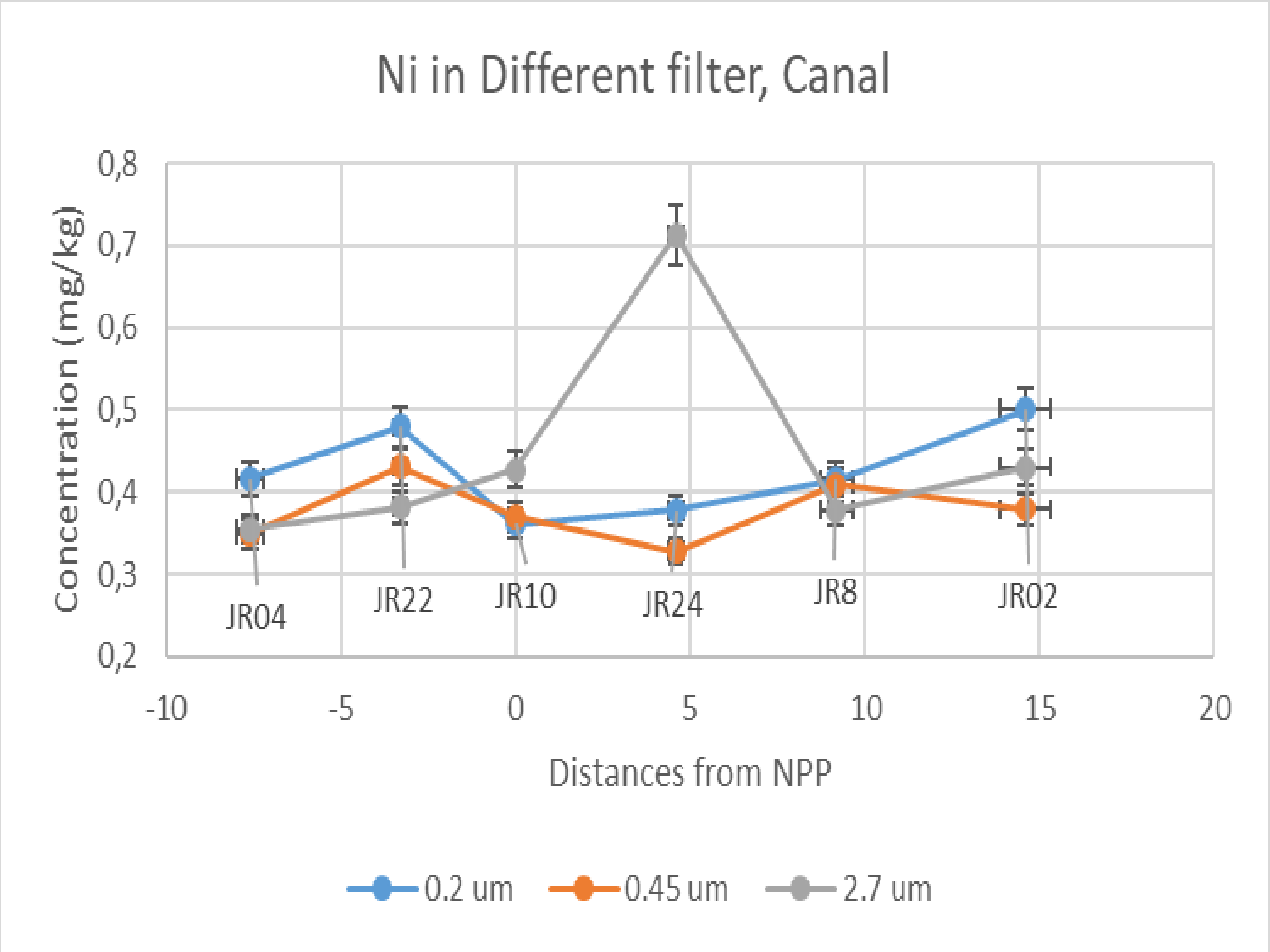
ZETA POTENTIAL

- Both systems have negative zeta potential values from -8 mV to -14 mV.
- The particle may not unstable and tend to make aggregates.

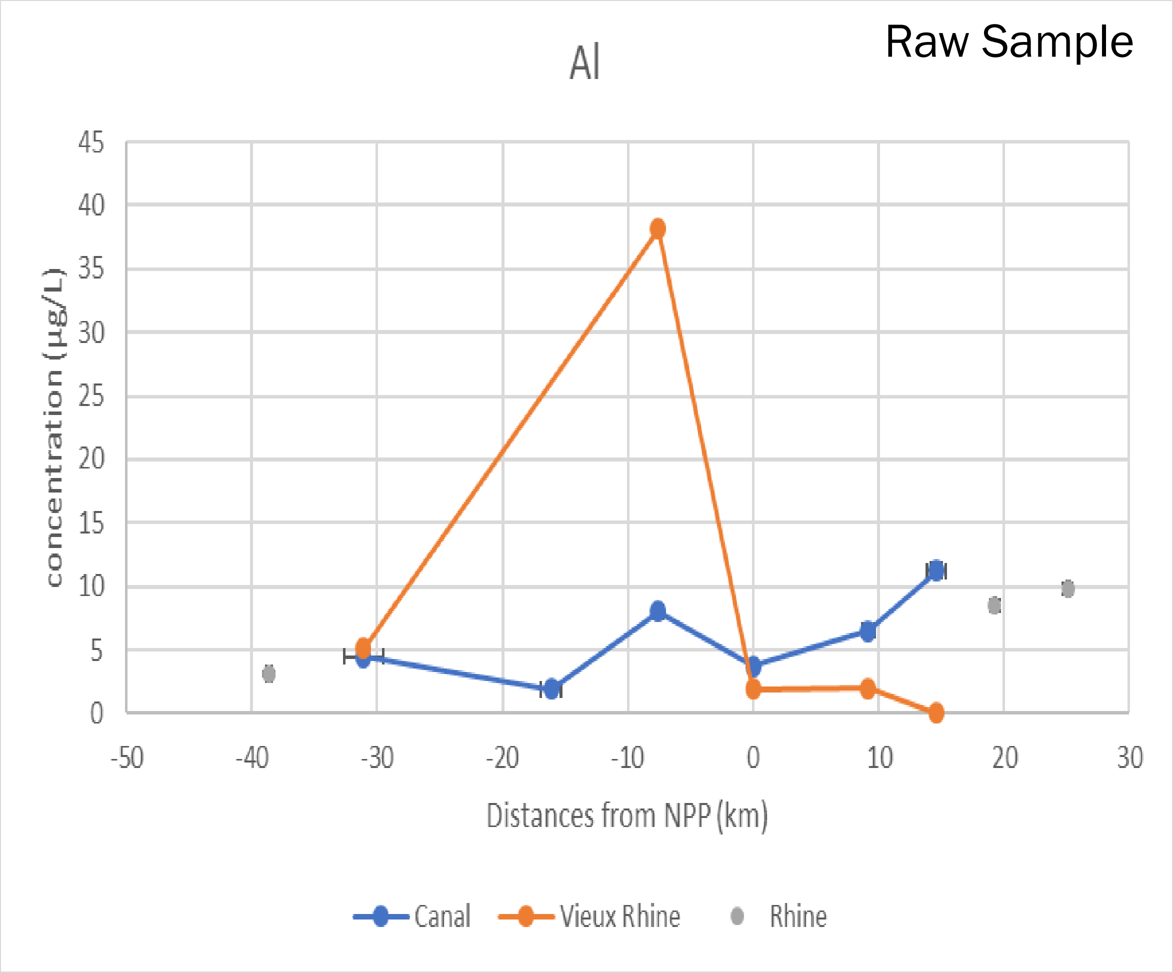


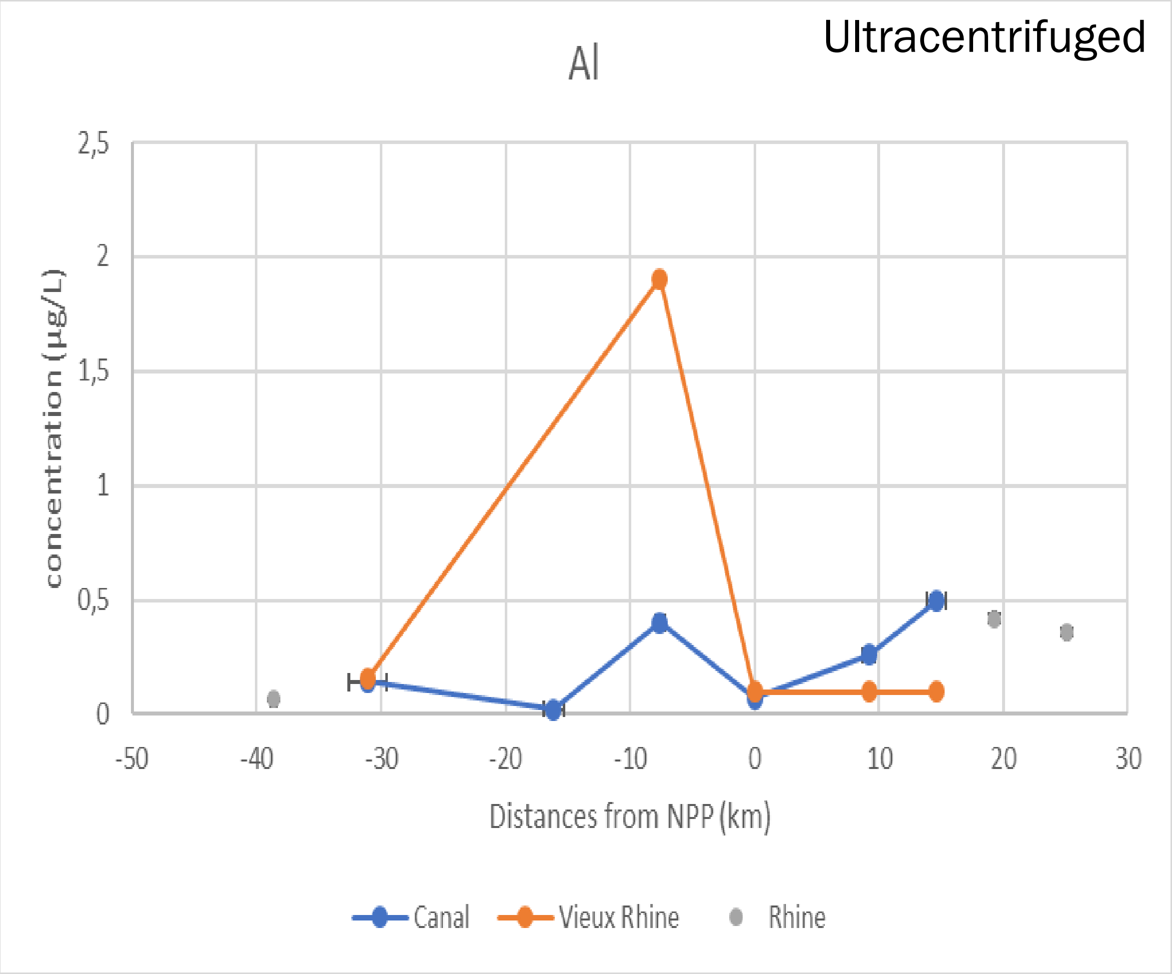
FILTRATION SAMPLE

- Possibility of nanoparticle present in near Fessenheim NPP.
- The same behavior found in data from the copper and zinc concentration.
- possibility to have nanoparticles (Ni,Cu and Zn) in GCA near Fessenheim NPP.



ULTRACENTRIFUGE SAMPLE





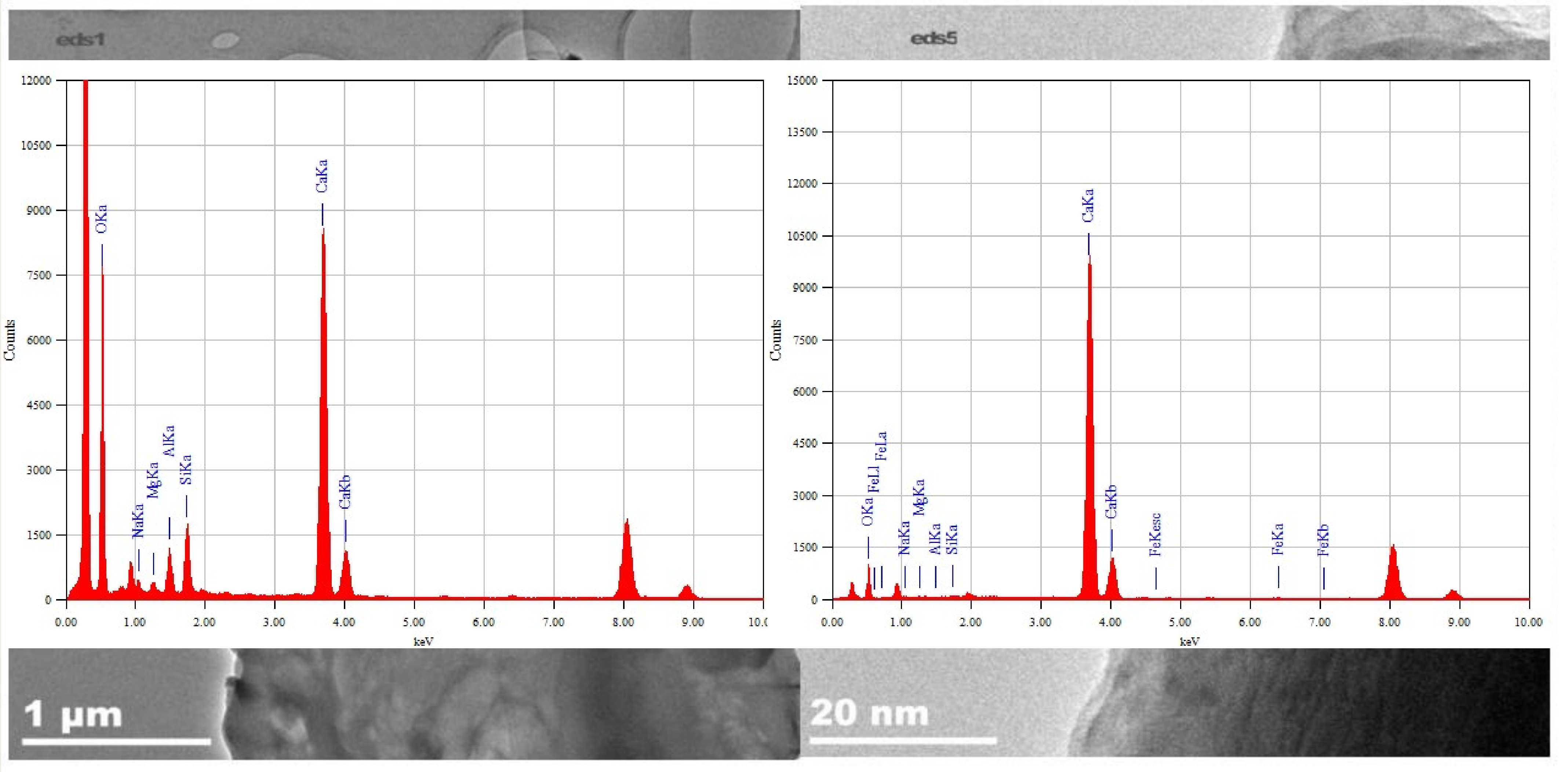
- Same Trend after centrifuged → indication of nanoparticle present

TRITIUM DISTILLATED SAMPLES

Sample Name	Location	Raw Sample Activities (Bq/L)	Distillated Sample Activities (Bq/L)
JR4	Canal	3.0 ± 1.3	2.2 ± 1.2
JR23	Old Rhine	2.0 ± 1.3	<LD

- Grand Canal Alsace → **free Tritium**
- Old Rhine → **bounded tritium**

RHINE RIVER RAW SAMPLES (UPSTREAM NPP)

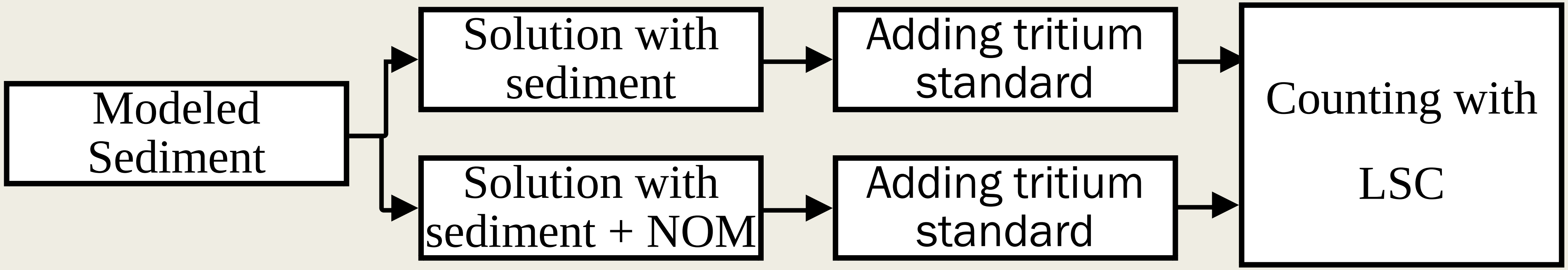


WHAT WE LEARNED ABOUT NANOPARTICLES

- GCA and Old Rhine → zeta potential : low negative surface charge
- Filtration sample → nanoparticle of zinc, nickel and copper in GCA, 5 km after NPP.
- Ultracentrifuge sample → nanoparticle of aluminum in old Rhine, 10 km before NPP.
- Distilated tritium sample → different form of tritium.
- TEM analysis → nanoparticle are present in old Rhine.

SEDIMENT ADSORPTION EXPERIMENT

SEDIMENT ADSORPTION EXPERIMENT



- The organic matter was collected in old Rhine (extracted and reconcentrated).
- Tritium standard → 10 µL , Activity = 74.1 Bq/L
- Ratio of sediment and organic matter = 0.2 mgC/m^2

SEDIMENT ADSORPTION EXPERIMENT

Solution	Activity of tritium added (Bq)	NOM added (mg)	mass of sediment added (mg)	Adsorption (%)	pH
Sediment	0,669	-	21	80	6.7
Sediment +NOM	0,717	0,19	20	86	7.2

→ Organic matter increases adsorption.

CONCLUSION AND RECOMMENDATION

CONCLUSION

- Water chemistry → GCA and old Rhine system have same evolution (pH, IC, Anions, Major Elements) BUT have different form of tritium.
- Nanoparticles (smectite and calcite) are present in the system → old Rhine : bounded tritium can be associated with these nanoparticles.
- Sediment adsorption experiment → tritium can be absorbed by sediment from the old Rhine river BUT the organic matter increase the tritium adsorption.

RECOMMENDATION

- LCA : These Results are not suficient to estimate tritium fate factors.
- Possibly other factor :
  - *pH.*
  - *Ratio of organic matter and sediment.*
  - *Composition of organic matter.*
  - *others possibly factor*

SKILL USED

- *Improved lab skill*
- *Improved presentation skill with wider audiences*
- *Intrepetate and analysis data*
- *Able to communicate and discus well with the team*
- *Learn new knowledge*

THANK YOU