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Contamination intensity and origin of trace metals in the bottom sediments from the Sebou basin (NW Morocco)

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Introduction

• The development of anthropogenic activities has a very visible impact on the quality of aquatic environments

(Hayzoun et al., 2015)

Input of contaminants

Affect bentic and humain health

Trace Metals (TM)

- Persistence
- Toxicity
- Bioaccumulation

(Volpe et al., 2009; Qiu et al., 2015)

• Sediments have a high retention capacity of trace metals

(Sight et al., 2005)

Introduction

- Studying river sediments allowed to assess the contamination of river by TM from both **natural** and **anthropogenic** sources

(Rodríguez, et al., 2005; N'guessan, et al., 2009)

- Five principals components of sediments control these metals : iron and manganese oxides, clays, organic matter, carbonates and the residual faction

(Leleyter et Probst, 1999)

- Semi-arid basins, characterized by long dry low-water periods, are mostly sensitive to trace metals contamination

(Neto, et al., 2017; Benabdelkader, et al.,2019)

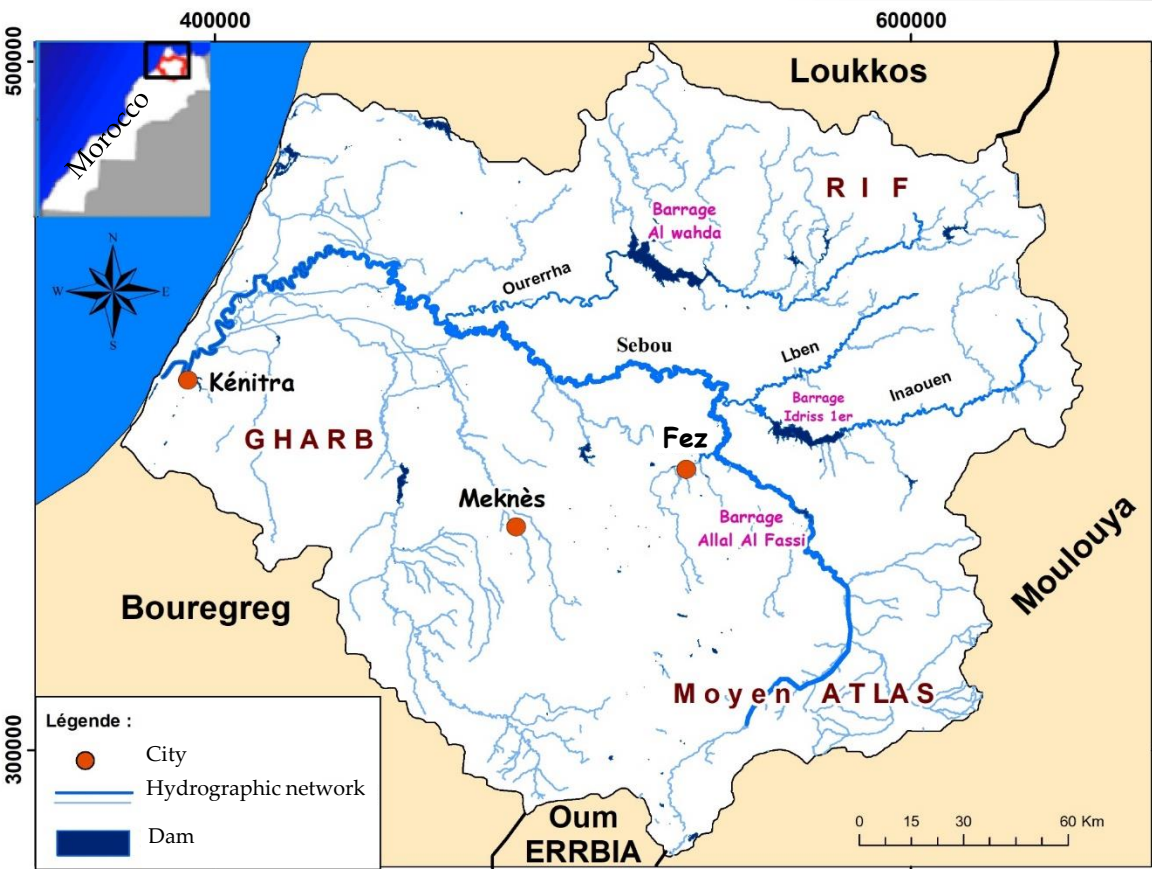
Sebou Basin :

- Carbonated basin
- 1/3 of the surface water resources of the country **(Lamhasni et al., 2003)**
- Population growth, development of artisanal, industrial and agricultural activities :

  Quality of the Sebou River **(Perrin et al., 2014)**

- None investigation on the scale of the basin
- Only punctual studies

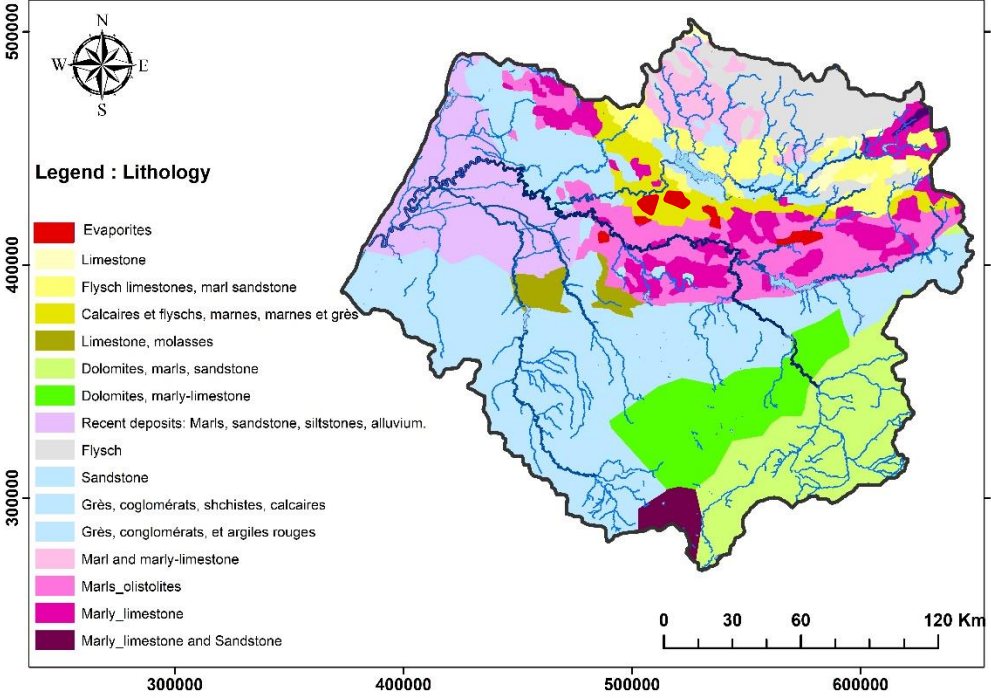
  (Koukal et al., 2004; Hayzoun et al., 2015 ; Bounouira et al. 2018, Hassimi et al., 2019)

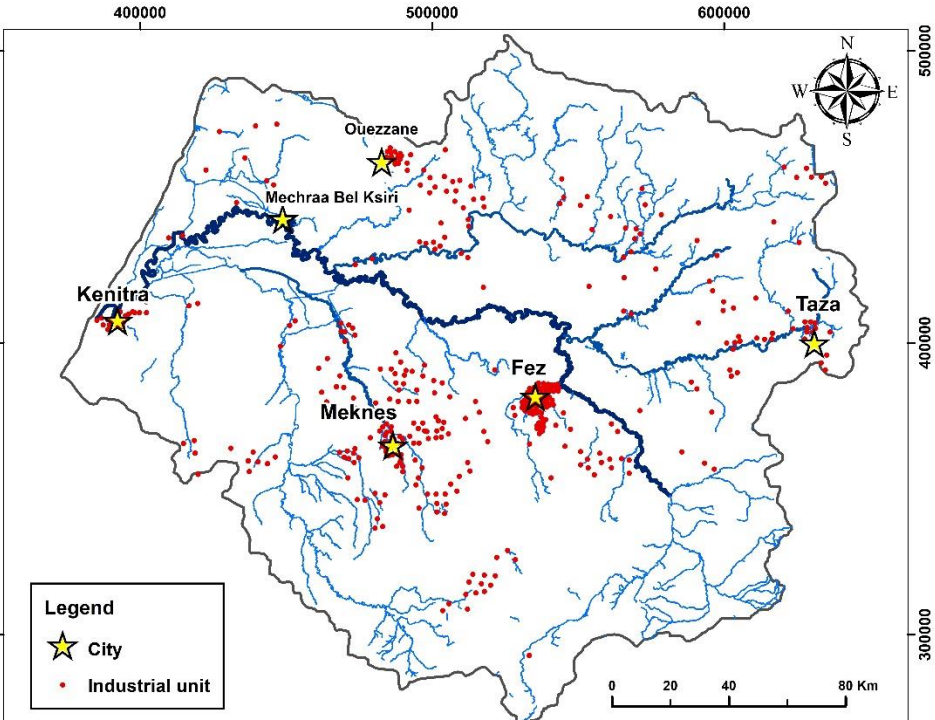


Introduction

Lithology

- Mainly carbonates and marl rocks with dominance of limestone and aluminosilicates.





Mean industrial activities

- Paper industry ➔ Fez, Meknes, Kenitra cities
- Textile industry => Fez city
- Tannery ➔ Fez, Meknes cities
- Agro-food industry ➔ Fez, Meknes, Taza, Ouezzane, Mechraa Bel Ksiri, Kenitra cities

Objectives

- **The main objectives of this study at the scale of Sebou basin:**

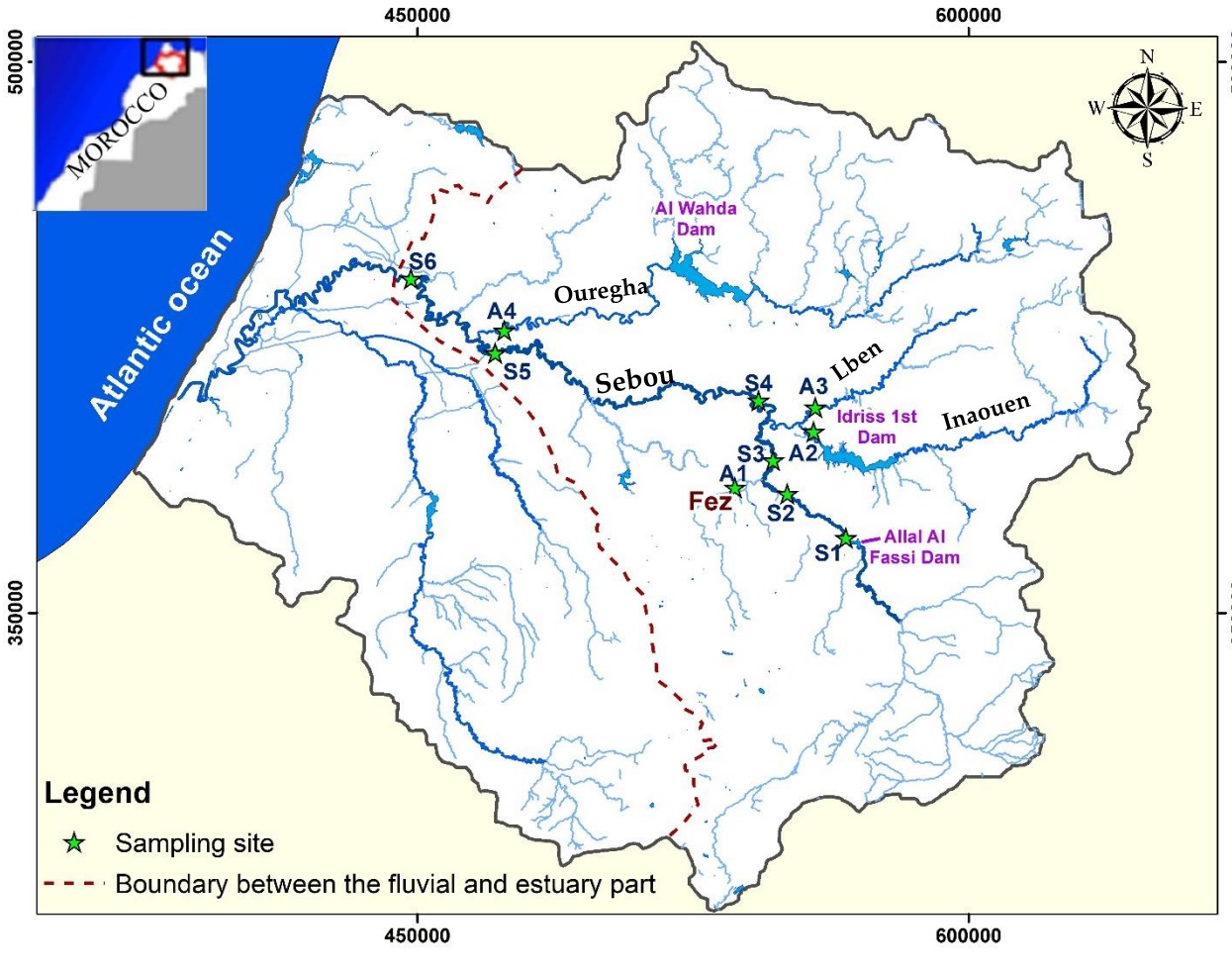
  - ✓ Assess TM contamination of river sediments
  - ✓ Investigate the natural and anthropogenic origin of TM in sediment
  - ✓ Identify the controlling factors of TM in sediment

Materials & Methods

*Sediments sampling

- Surface sediments (0-5cm)

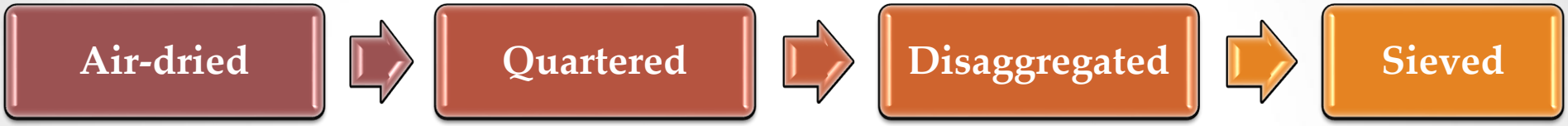
- 10 Stations on the fluvial part of Sebou basin (delimited by the red dash line) :
  - Sebou River (Code S) and its main tributaries (Code A) (Fez, Inaouen, Lben and Ouergha)



- Four sampling campaigns : contrasted hydrological periods and seasons

Materials & Methods

*Pre-treatment of sediment samples



*Physico-chemical treatments and analysis

- Micro-granulometric analysis (Total (≤ 2 mm) and fine fraction (≤ 63 µm)) : Horiba LA 950 laser microgranulometry.
- Particulate organic carbon (POC) (Fraction <63µm): Flash 2000 ThermoFisher (after a inorganic carbon removal with hydrochloric acid (HCL, 2N))
- Total concentrations of major and trace metals (fraction <63µm) : Alkaline fusion method with lithium metaborate ➔ ICP-MS

*Enrichment Level Assessment : Enrichment Factor

$$EF = (X/R)_{Sample}/(X/R)_{Background}$$

- X : Trace metal
- R : Normalizing element
- Background : Reference material (most suitabale than UCC)

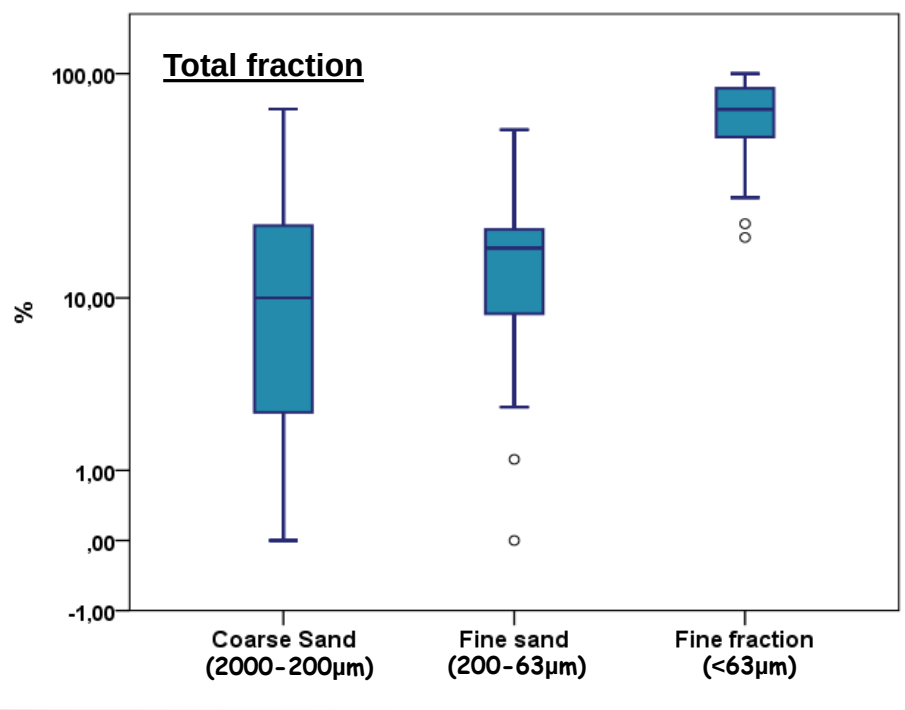
(Chester and Stoner, 1973)

➔ **Aluminium** : Normalizing element

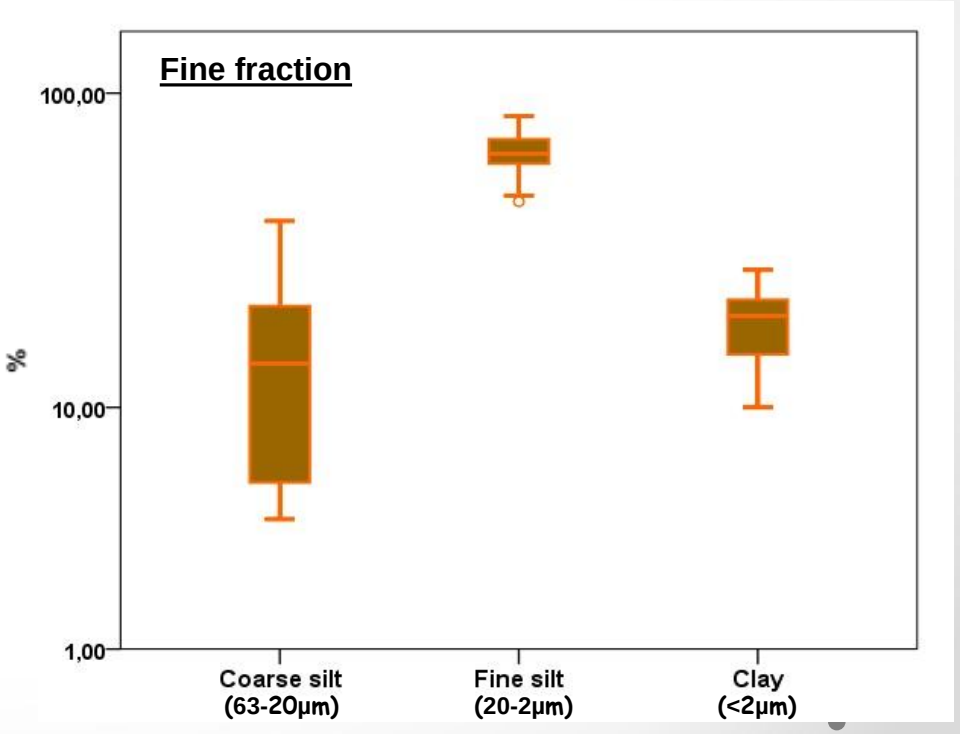
➔ **Tafna basin bedrock** (Algeria, Benabdelkader, et al., 2018) : Reference material (most suitable than the Upper Continental Crust (UCC, Wedepohl,1995)

Results & discussion

*Particle size analysis



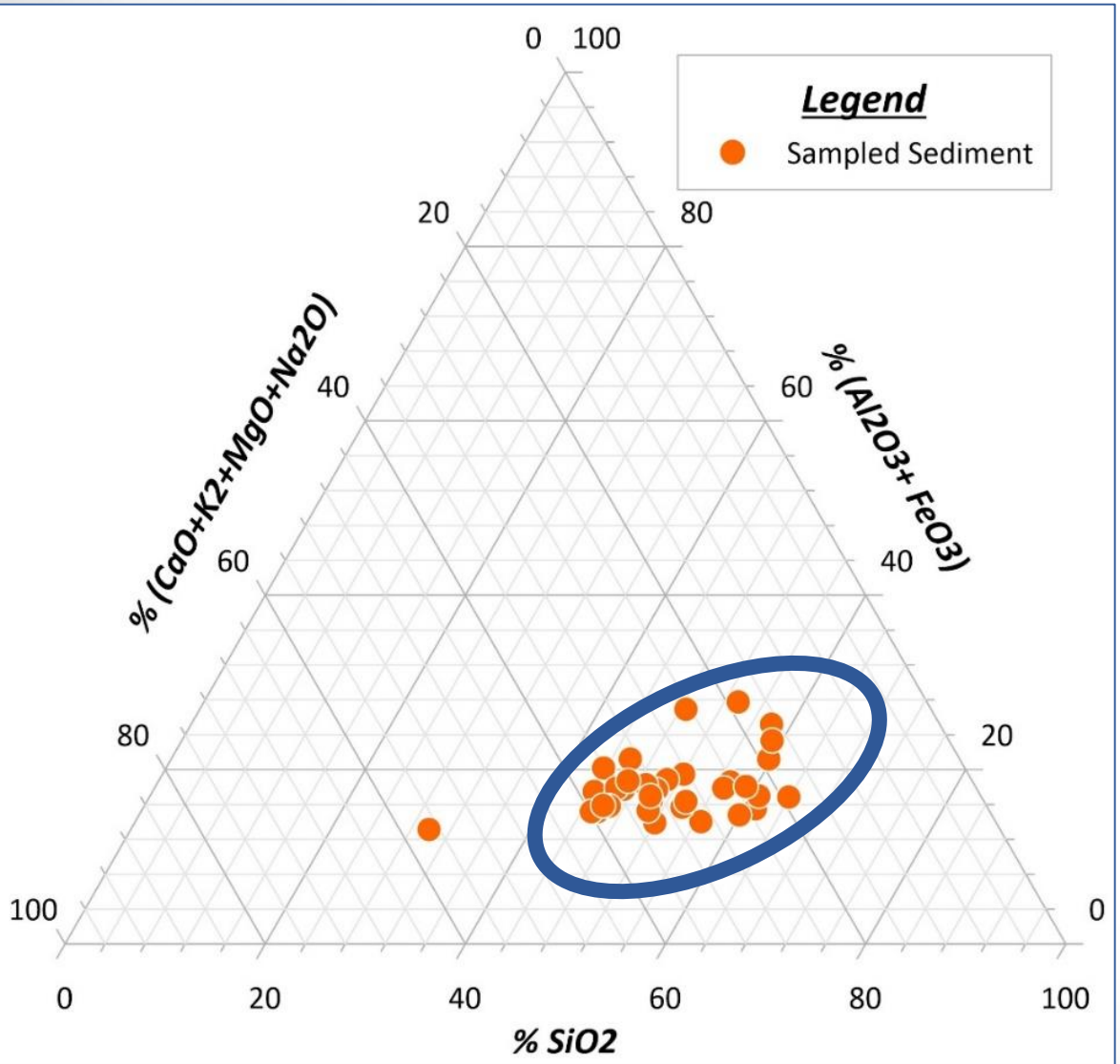
- Total fraction (≤ 2 mm) : 76% of samples contain more than 57% of fine fraction (≤63 µm)



- Fine fraction (≤63 µm) : dominated by fine silts with mean values of 66 %

Results & discussion

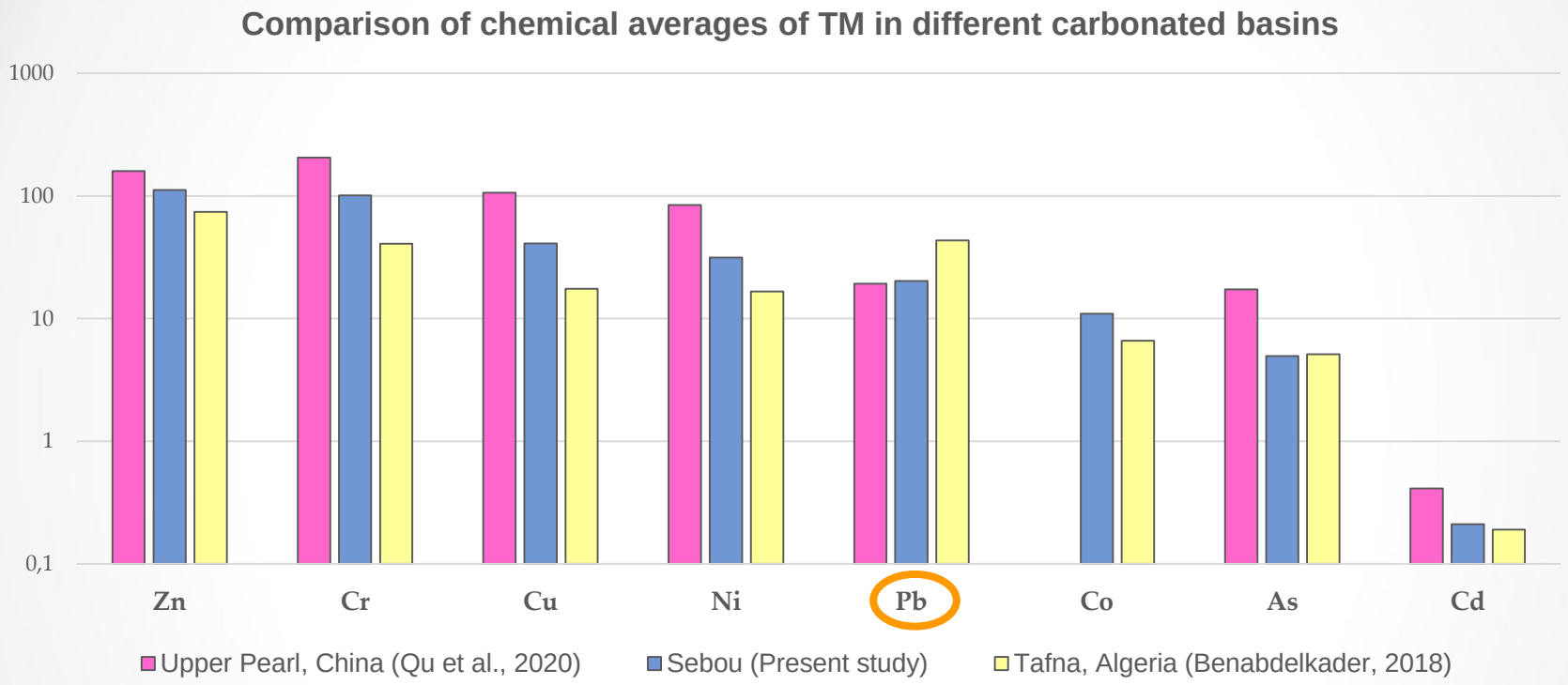
*Major elements



- **Si**, **Al**, **Fe**, **Ca**, **Mg**, **K**, and **Na** constitute more than **75%** of the **geochemical composition of the sediments**.

Mainly explained by the bedrock (chemical weathering)

*Trace metals



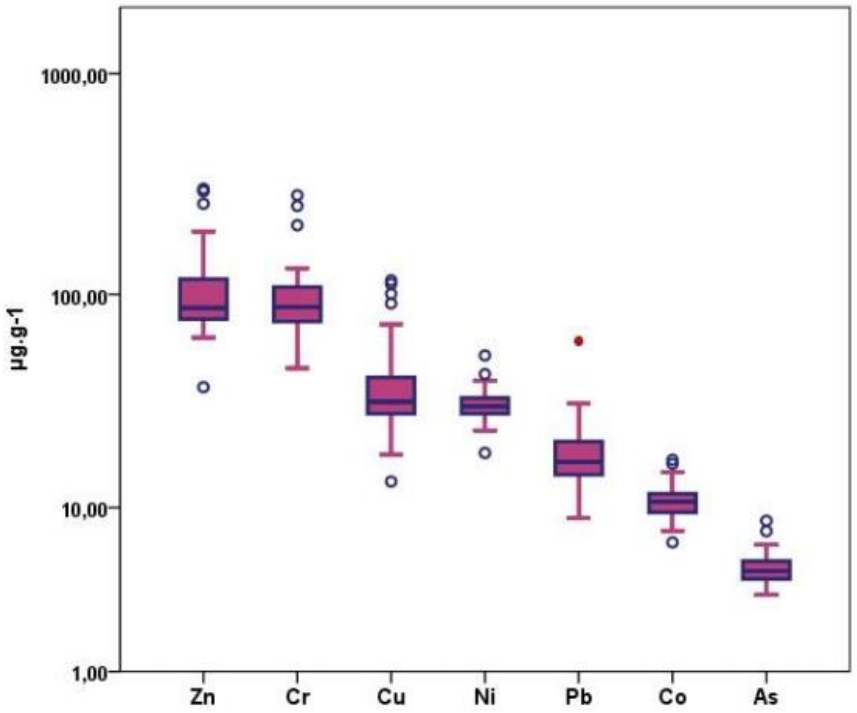
➔ Tafna < Sebou < Upper Pear

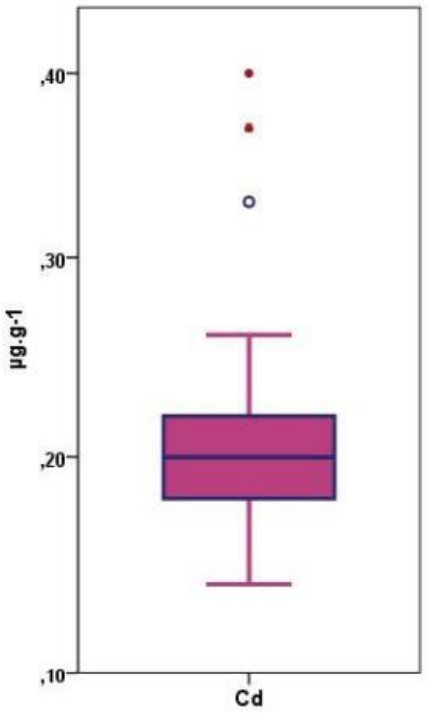
Except Pb

- Geographically : Sebou close to Tafna ➔ Same Atlas massif

*Boxplot of trace metals concentrations

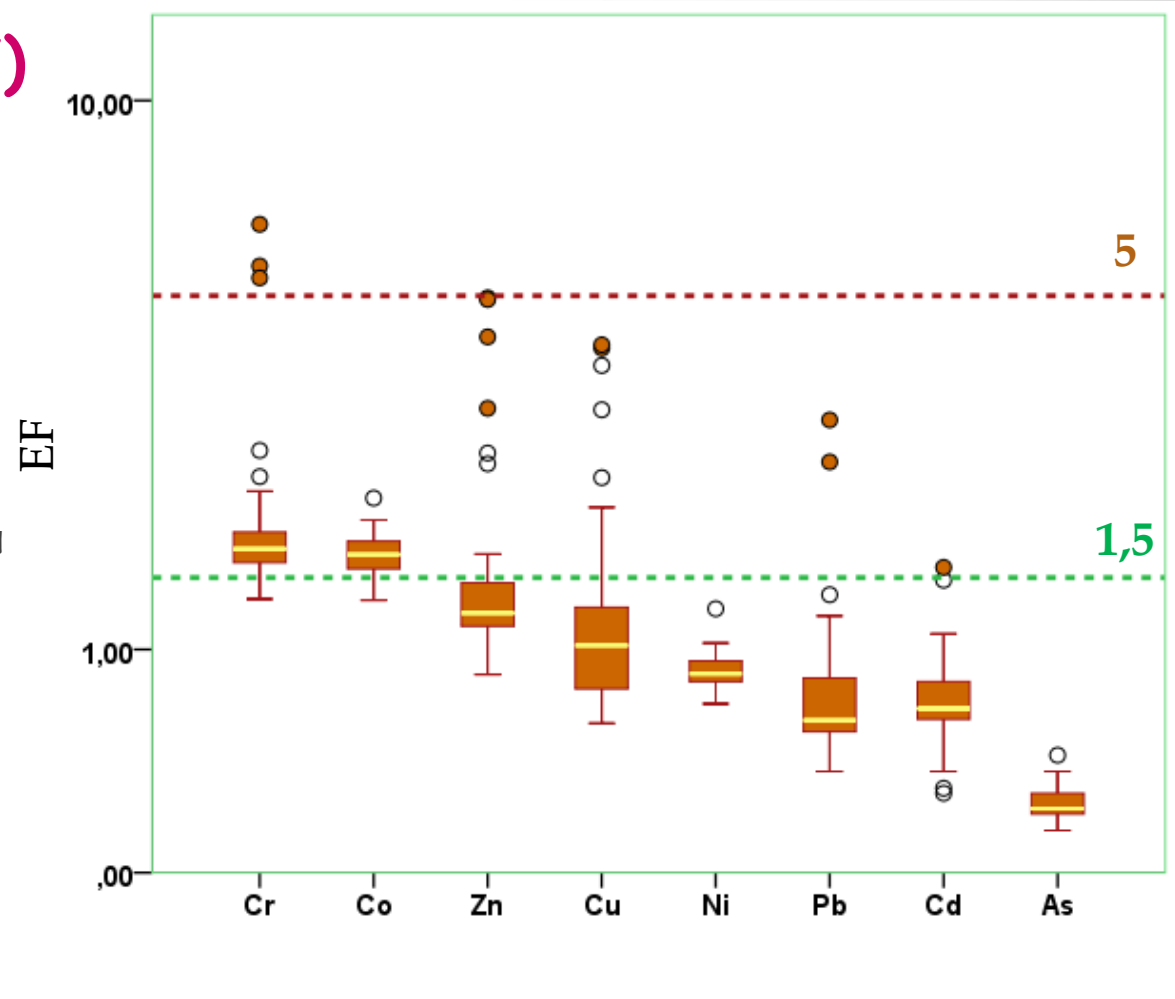
- Standard deviation : higher dispersion of concentrations for Zn, Cr and Cu
- Highest concentrations :
  - Cd, Cu, Cr, Zn, and Pb ➔ S3 Station
  - Ni ➔ A1 Station
  - Co ➔ A3 and A4 stations





*Enrichment Factor (EF)

- 70% samples ➔ naturally enriched TM (EF≤1,5)
- Highest EF values : Zn, Cr, Cu and Pb : S3 station.
- High enrichment was also observed :
  - Zn, Cu, Pb : A1 Station
  - Cu and Cr : S4 Station



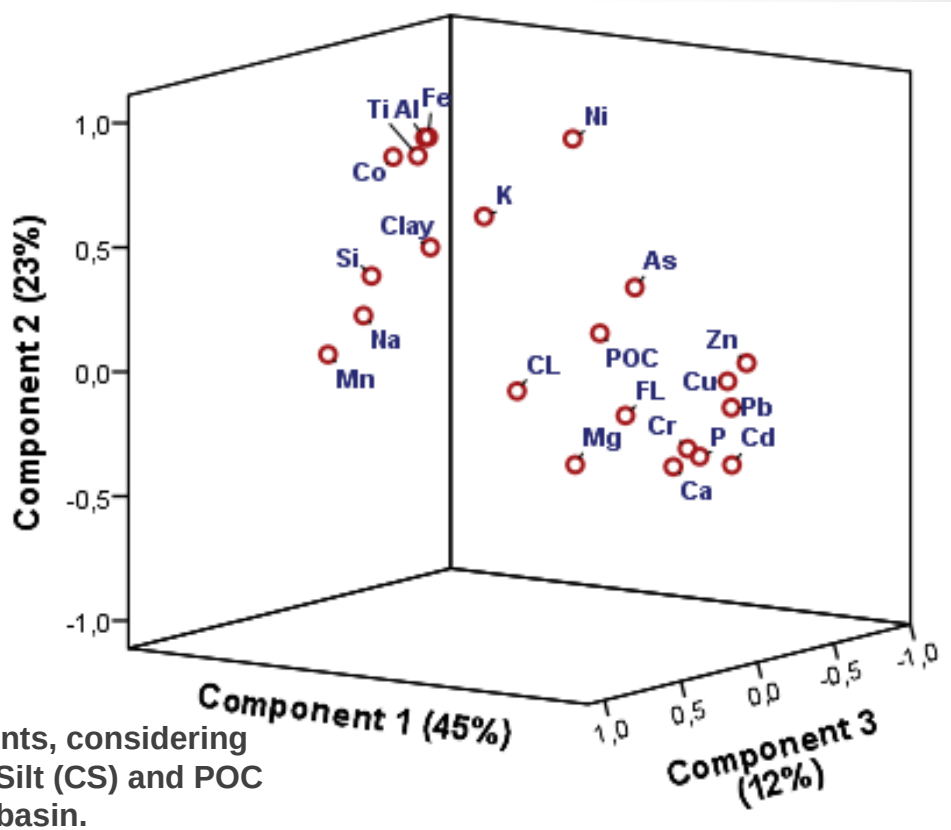
*Controlling factors of TM

Principal component analysis (PCA) :

- **Zn**, **Cr**, **Cu**, **Pb** and **Cd**, strongly linked to P : Most anthropogenically influenced (related to component 1)
  - ➔ Mostly originated from domestic waste waters, industrial discharge (Cr from artisanal activity of Fez city) and potentially fertilizers

- **Ni** and **Co** : Least anthropogenically influenced and controlled by oxydes (Al, Fe and Ti) (related to component 2)

- **As** is of natural carbonate weathering origin (strongly linked to Ca) negatively to silicate (Si and Na) (related to component 3)



3D representation of PCA for the three main components, considering metal and major elements, Clay, Fine Silt (FS), Coarse Silt (CS) and POC content in bottom sediments of the Sebou basin.

Conclusions

- The result of TM concentrations in river sediments did not show alarming concentrations, except for Cr, Zn and Cu (specially downstream of the city of Fez)

- Each TM behaves differently depending on its origin and its controlling factors

- The EF and Principal Component Analysis (PCA) allowed identified natural and anthropogenic origin and controlling factors :
  - Most anthropized elements : Zn, Cr, Cu, Pb and Cd linked to P
  - Less impacted by anthropic activity elements : Ni and Co controlled by oxydes (Al, Fe and Ti)
  - Natural origin element : As controlled by carbonate (linked to Ca)

- To assess the potential risk of enriched trace metal, it is necessary to evaluate their availability using extractions procedures (El Mrissani PhD, in progress)

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