



**Environmental and health impacts of hazardous metals  
from tailings to products**



Jillian Helsler<sup>1,2</sup>; Valérie Cappuyns<sup>1,2</sup>

<sup>1</sup> Department of Earth and Environmental Sciences, KU Leuven, 3001 Leuven, Belgium  
<sup>2</sup> Center for Economics and Corporate Sustainability, KU Leuven, Brussels B-1000, Belgium

**Objectives, Milestones + Deliverables**

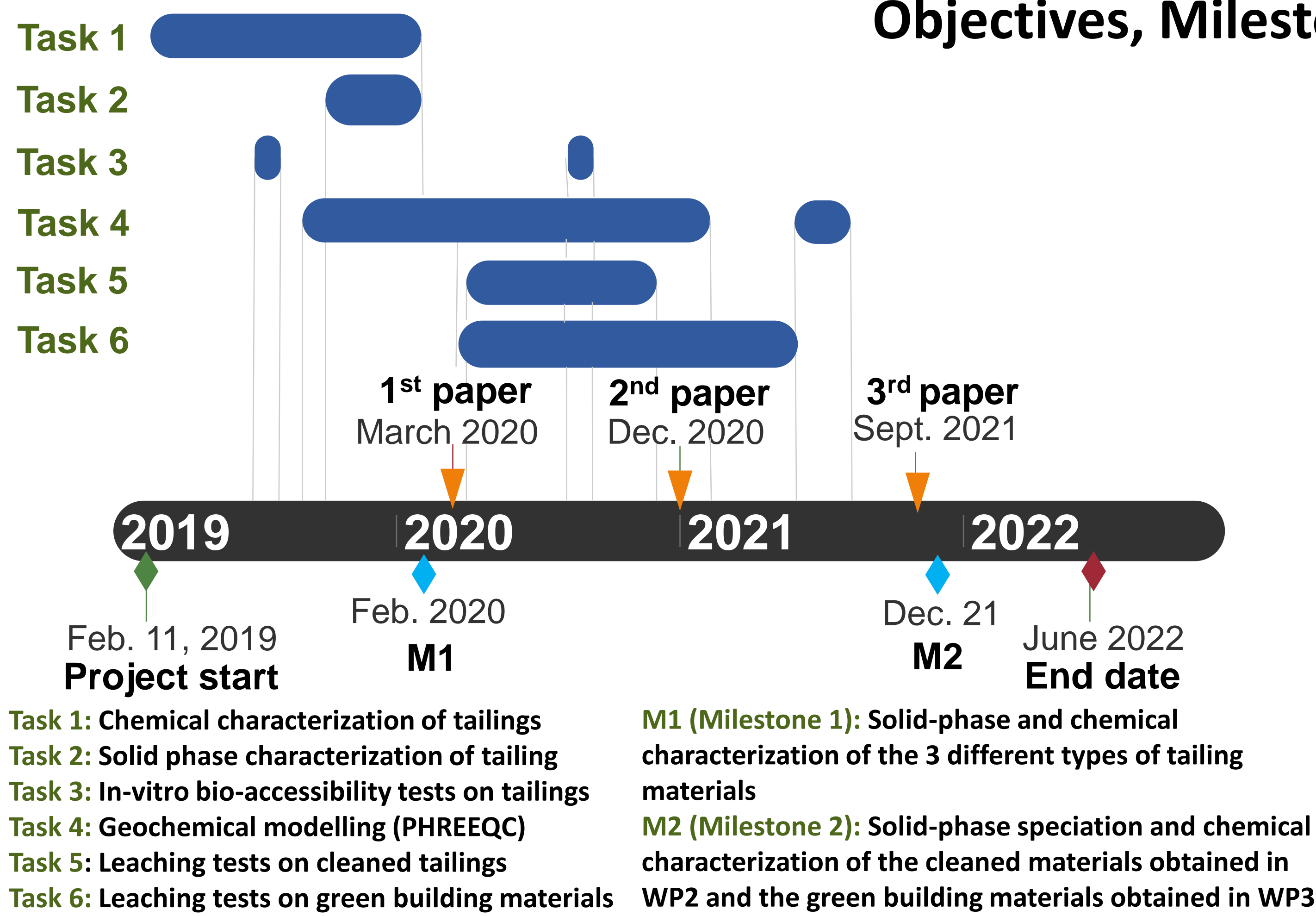


Figure 1. Gantt chart outlining the tasks, milestones and main deliverables of the research project.

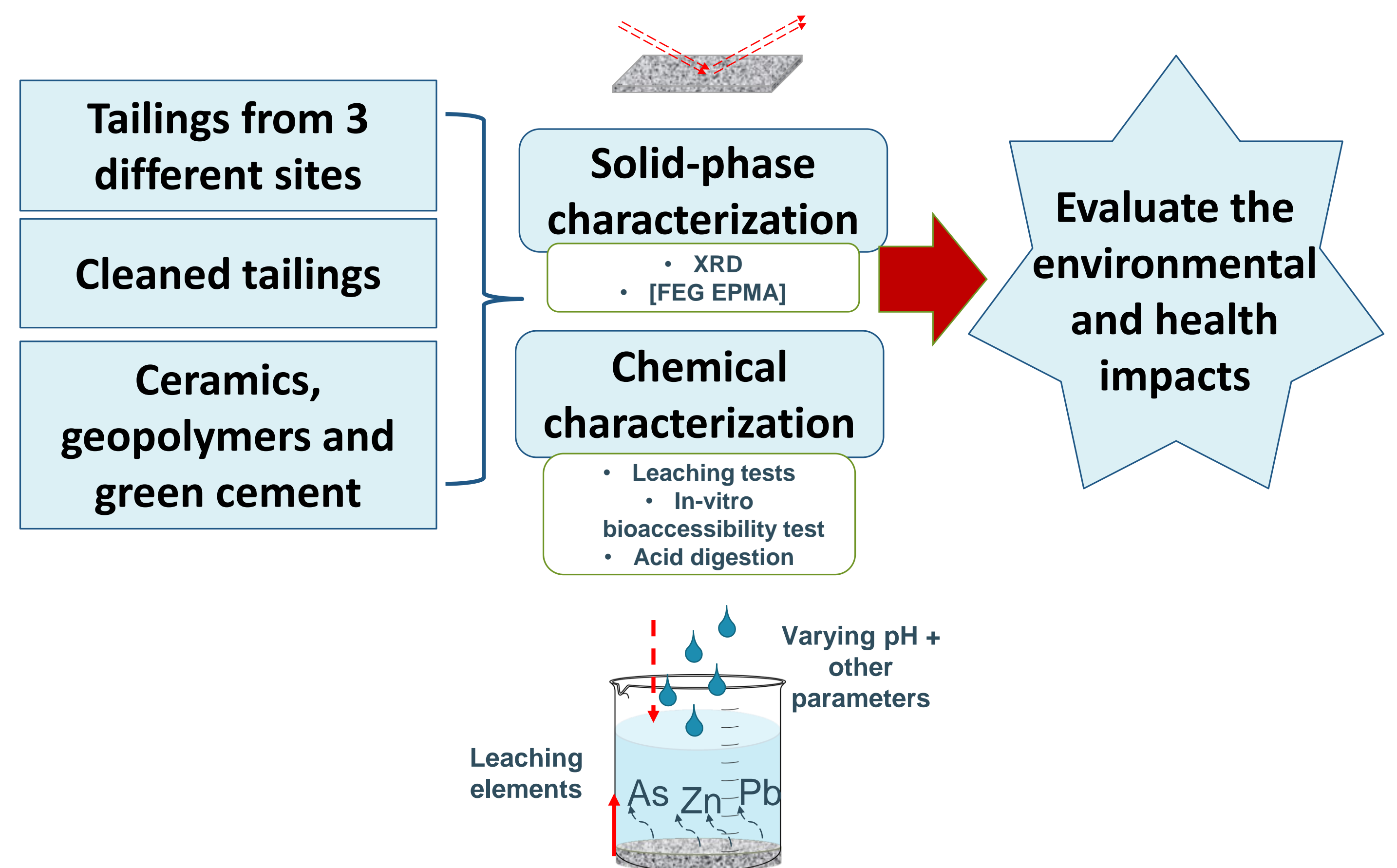


Figure 2. Schematic diagram encompassing the main objectives of the project, including the different characterization methods.

**Methodology:**

Table 1. List of 13 samples (including 9 official SULTAN samples i.e., SUL\_XX\_XX and 4 additional Plombières samples) with their respective pH

Samples	pH
PL_31	7.4
PL_32D	6.5
PL_36B	6.8
PL_37A	6.0
SUL_FR_01	4.0
SUL_NC_01	6.1
SUL_NC_02	4.3
SUL_NC_03	3.5
SUL_PL_55I	7.8
SUL_PL_62I	7.3
SUL_PL_62J	6.7
SUL_PL_65A	6.1
SUL_PL_66A	6.8

**Sample preparation: Samples were oven dried at <45°C and crushed with a mortar to <500 µm**

Table 2. Details of parameters (Liquid solid (L/S) ratio, extraction fluid used and duration of experiment) for 5 leaching tests and 1 in-vitro bioaccessibility test. \*Leachates were analyzed using ICP-OES for 23 trace elements

Test	L/S ratio	Extraction fluid	Time
<b>Resuspension test</b> (Cappuyns et al., 2006)	10	Deionized H <sub>2</sub> O	>1 year (ongoing)
<b>Toxicity characteristic leaching procedure</b> (USEPA Method 1311)	20	Acetic acid + NaOH (pH~4.9)	18 hrs
<b>EN12457-2</b> (BS EN 12457-2:2002)	10	Ultrapure MQ H <sub>2</sub> O	24 hrs
<b>pH-dependence leaching test</b> (Modified CEN/TS 14429:2005)	10	Nitric acid and NaOH at varying concentrations (pH 0.5, 1, 2, 3, 6, 9, 11, 13)	2, 6, 24, 48 hrs
<b>Cascade leaching test</b> (NEN 7349, 1995)	10; cumulative: 100	Ultrapure MQ H <sub>2</sub> O	2 weeks
<b>In-vitro modified bioaccessibility extraction test</b> (US EPA, 2007)	50	Simulated gastric fluid: Glycine acidified with HCl (pH 1.5) Simulated intestinal fluid: Addition of NaHCO <sub>3</sub> (pH 7)	1 <sup>st</sup> phase: 1h 2 <sup>nd</sup> phase: 3h

**Research Results:**

**Aqua regia digestion**

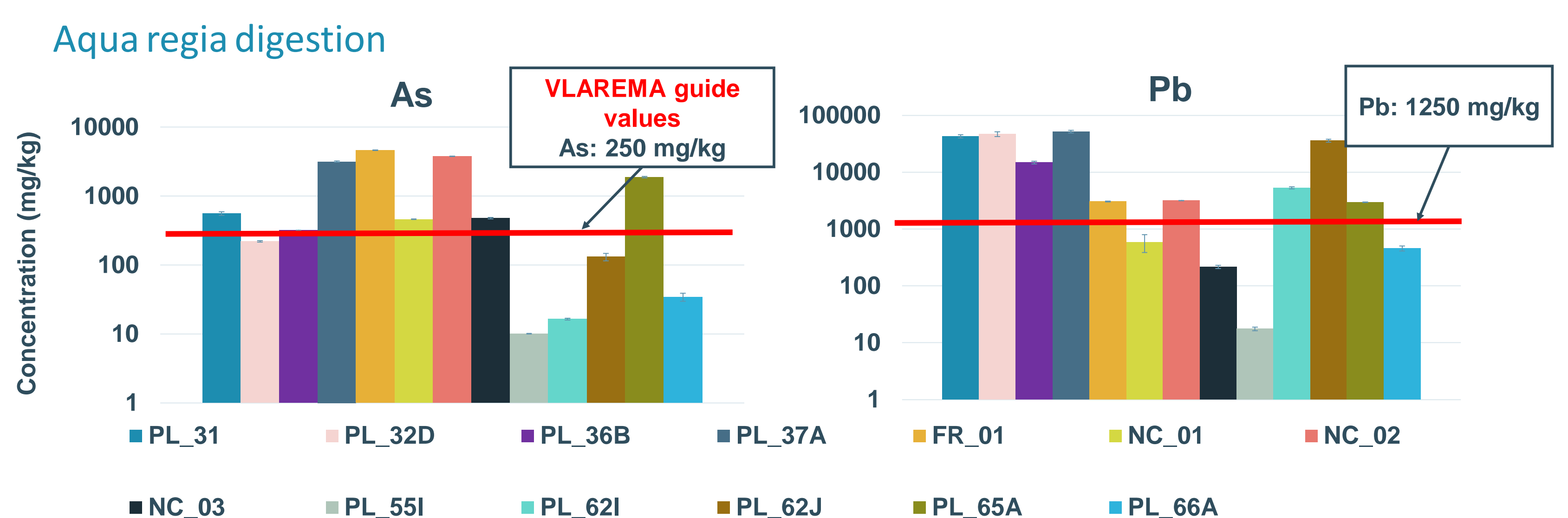


Figure 3. The concentration of As and Pb of each of the samples based on aqua regia digestion (modified ISO 11466 method), in comparison with the Flemish VLAREMA guide values (horizontal red line) of the total concentrations allowed to be used as a building material in Flanders.

**pH dependence leaching test, in-vitro bioaccessibility test, and EN 12457-2 for SUL\_FR\_01**

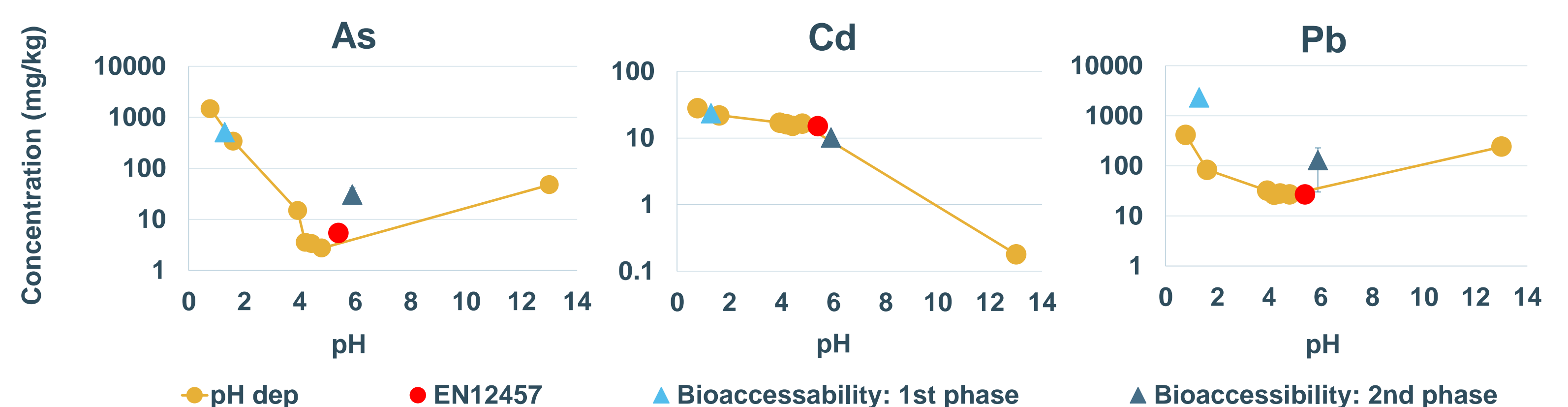


Figure 4. Concentrations of As, Cd and Pb leached in relation to the pH during the pH dependence leaching test (pH dep) in comparison with the EN12457-2 test (EN12457) and in-vitro modified bioaccessibility test phase 1 (bioaccessibility 1<sup>st</sup> phase) and phase 2 (bioaccessibility 2<sup>nd</sup> phase) of sample SUL\_FR\_01.

**Conclusions**

- Mineralogy of Plombières samples consists mostly of amorphous phases and quartz
- pH and L/S ratio are the most significant determining factors for leaching of elements
- Total concentrations of As and Pb (Aqua regia digestion), for most samples are above VLAREMA guide values for total concentrations allowed for use as or in building materials

**Upcoming steps**

- Valorize SULTAN tailings by using different binders, such as geopolymers and ceramics (during secondments at University of Oulu (Finland) and Wienerberger (Belgium))
- Perform chemical characterization on building materials (made with SULTAN tailings) and cleaned tailings (upon availability)
- Continuation of resuspension experiment and validate results with PHREEQC geochemical model



Figure 5. Photo of resuspension experiment (month 6) samples SUL\_NC\_01, SUL\_NC\_02, SUL\_NC\_03 and SUL\_FR\_01 (left to right).

