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## **A new experiment to assess the impact of groundwater table level variations on petroleum hydrocarbon pollutants remobilization (LNAPL) in the climate change context**

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# A new experiment to assess the impact of groundwater table level variations on petroleum hydrocarbon pollutants remobilization (LNAPL) in the climate change context.



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## LIGHT-NON-AQUEOUS-PHASE-LIQUIDS (LNAPLs)?

|   |   |
|---|---|
| Origin                                      | Petroleum hydrocarbons (oil, gasoline, diesel fuel)                 |
| State and density                           | Viscous liquids, density < 1 g/cm <sup>3</sup>                      |
| Origin                                      | Saturated/unsaturated hydrocarbons (mainly normal-alkanes) and BTEX |
| Occurrence                                  | ~ 45% of contaminated soils and groundwater tables                  |
| Residence time                              | > 10 years  |
| Solubility, Biodegradability and Volatility | Low to moderate, dependent on the LNAPL compounds                   |



## LNAPLs AND GROUNDWATER

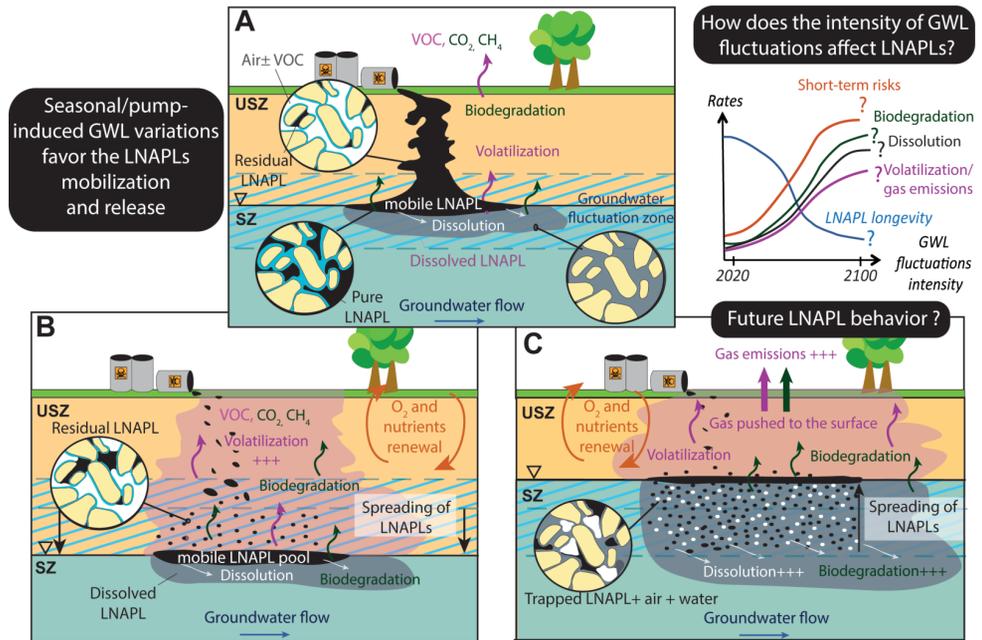


Fig.2. LNAPL mobilization and release processes during groundwater table level (GWL) fluctuations: (i) initial, (ii) low (dry season), (iii) high water table level (wet season). VOC: volatile organic carbon. SZ: saturated zone. USZ: unsaturated zone.

## GROUNDWATER AND CLIMATE CHANGE

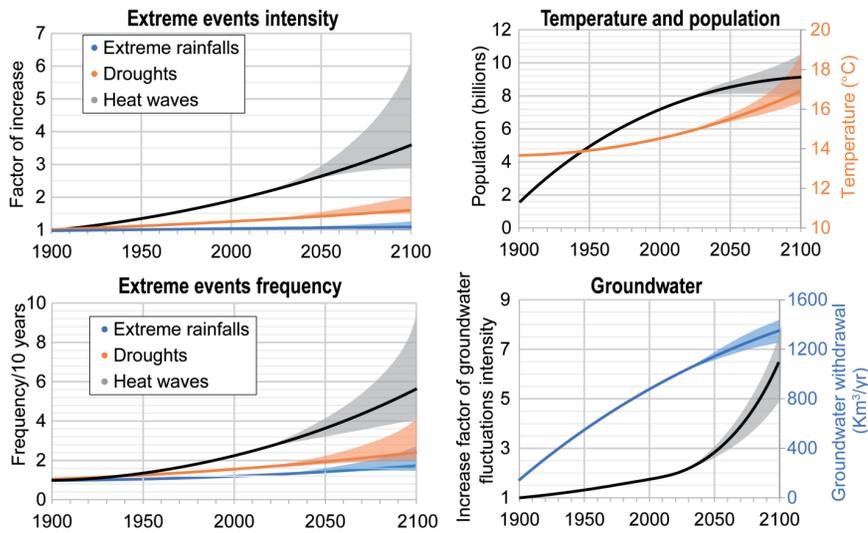


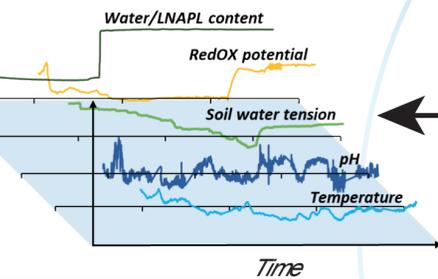
Fig.1. Measured and projected evolutions of the global earth surface temperature, population growth, extreme events intensity and frequency, groundwater withdrawal and groundwater table level variations intensity from 1900 to 2100. After the data of the IPCC (2021), the European Environment Agency, and Wada (2016) <https://doi.org/10.1007/s10712-015-9347-x>.

### CLIMATE CHANGE MAY:

- o Change precipitation and groundwater recharge patterns (Fig.1)
- o Increase groundwater use, decrease the average water table level.
- o Increase the amplitude of variations in the groundwater table level.
- o Favor the vertical spreading of the LNAPLs across the soil
- o Favor the short-term LNAPL release to the air and water
- o Increased long-term LNAPL natural attenuation rates

## IN THE LABORATORY

### LYSIMETRIC EXPERIMENTS



## HOW DO WE STUDY THESE PHENOMENA?

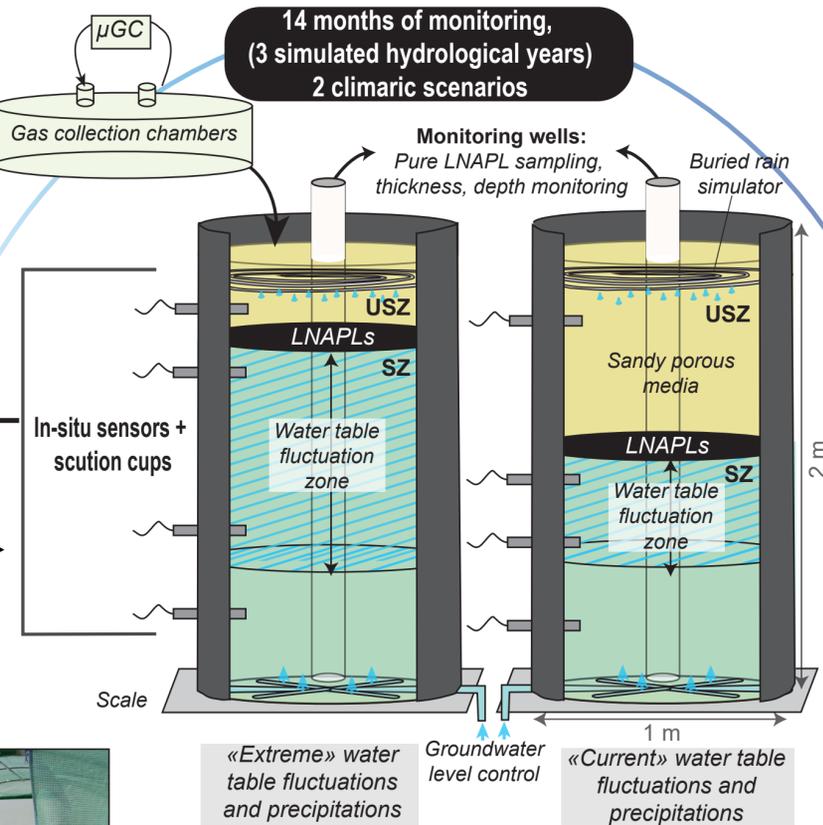
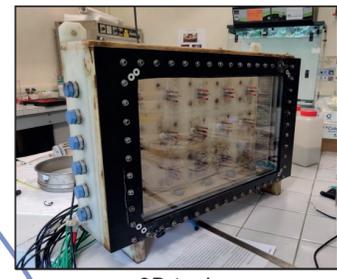


Fig. 3. Experimental setup used to simulate the effect of two scenarios (current and extreme/climate change) of precipitations and groundwater level variations on LNAPL contaminated sand. Start in October 2021

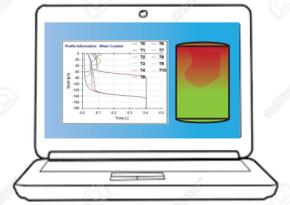


2D tanks

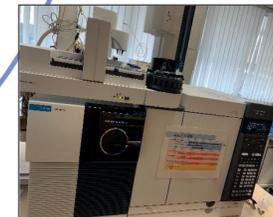


1D centimetric columns

Calibrations of tensiometers, electrical permittivity and resistivity data under controlled LNAPL/water/air saturations in the laboratory



Numerical simulation of LNAPLs transport and mobilization under fluctuating groundwater level from the pore scale to the lysimetric scale



GC/MS apparatus



Contaminated water samples analytical protocol improvements

### WHAT WE MONITOR?

- o Gaseous surface emissions (flux, composition: O<sub>2</sub>, CO<sub>2</sub>, hydrocarbons)
- o The LNAPL saturation distribution in soil (48 electrical resistivity and permittivity in-situ sensors per lysimeter);
- o Other soil properties: 4 in-situ sensors for temperatures, pH, RedOX, soil water potential at different depths.
- o The concentration and composition of the dissolved LNAPL phase: sampling using suction cups and laboratory analysis (SPE, GC/MS, TPH, DOC, FTIR)

### EXPECTED GOALS:

- o Improve monitoring techniques of contaminated sites
- o Improve the understanding of LNAPLs behavior under various climatic conditions
- o Help to adapt remediation methods in the climate change context

### PERSPECTIVES:

- o Consider the effect of biodegradation in the climate change context
- o Real-time contaminated sites monitoring (field scale).
- o Effect of increasing temperatures ?

