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WECARE Project - Wastewater treatment plants: an active source of Emerging Contaminants into Atmosphere?

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Context and objectives

- ❖ Environmental studies are mostly focused on the occurrence and fate of **emerging contaminants** (ECs - such as pharmaceuticals, UV-filters or perfluorated compounds), in aqueous environments. In contrast, less attention is paid to the **atmospheric compartment**, which plays a significant role in the **global cycling of pollutants**.
- ❖ In **wastewater treatment plants (WWTPs)**, ECs are frequently detected at concentrations ranging from ng/L to µg/L.
- ❖ **Aeration basins** in WWTPs have been identified as **sources of (bio)aerosols**, produced through mechanisms similar to those generating **sea salt particles**.^{1,2}
- ❖ Recent studies pointed out that **ECs may be adsorbed or trapped on atmospheric particles** and transferred into the atmosphere through bubble bursting (Figure 1).³⁻⁶
- ❖ The presence of high concentration of ECs in **treated sewage sludge** (µg/kg or mg/kg) raises concerns that **land applications of biosolids** may result in a transfer of ECs in the atmosphere.
- ❖ Additionally, secondary organic aerosol formation can also be observed from organic precursors emitted from WWTP activities.

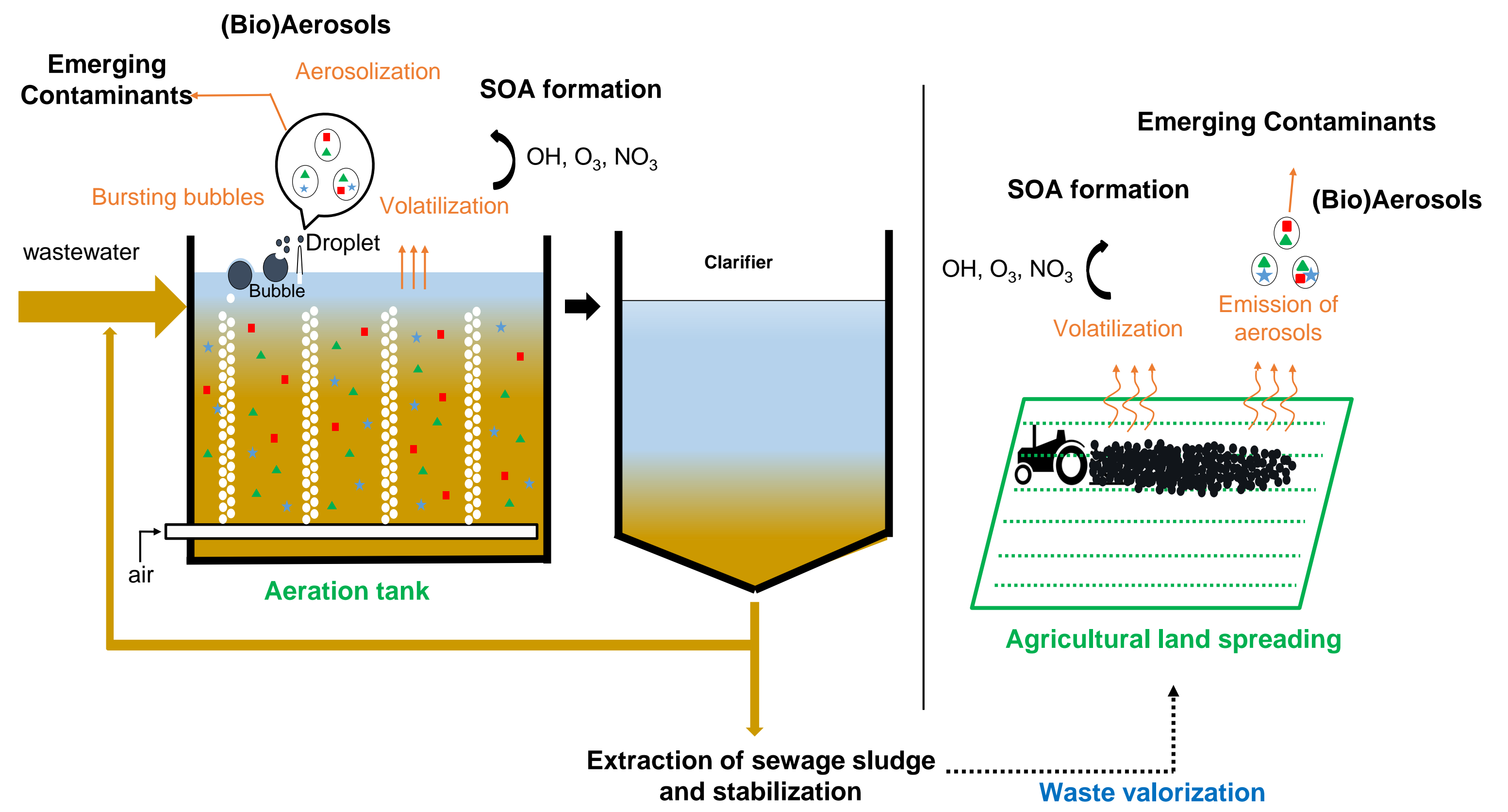


Figure 1. Key processes studied in WECARE project. Aerosolization/Emission of aerosols and volatilization processes from (a) aeration tank and (b) agricultural land spreading

The research objectives (RO) of WECARE project are the following:

RO1 To define and develop analytical techniques to identify and quantify ECs in the atmospheric compartment.

RO2 To characterize the emissions of gaseous and particulate ECs in the atmosphere from WWTP activities and describe transfer processes.

RO3 To evaluate atmospheric implication of ECs through gas-partitioning measurement, particulate size partitioning and estimation of emission fluxes.



Bibliography

Scientific work packages

WP1: Define and Develop complementary analytical techniques to identify and quantify ECs in the atmosphere

- Selection of 15-20 target ECs with **diverse chemical structures and properties**
- Development of extraction methods in two atmospheric sample matrices : **filters** and **polyurethane foam (PUF)**



- Development of **Off-line mass spectrometry** (including gas and liquid chromatograph) and **On-line mass spectrometry techniques**.
- Application of **Non-target methodologies** (chemical fingerprints).



WP2: EC emissions at pilot scale level – Laboratory experiments

Evaluate the emission of ECs from wastewater treatment activities in controlled experimental conditions (Figure 2).

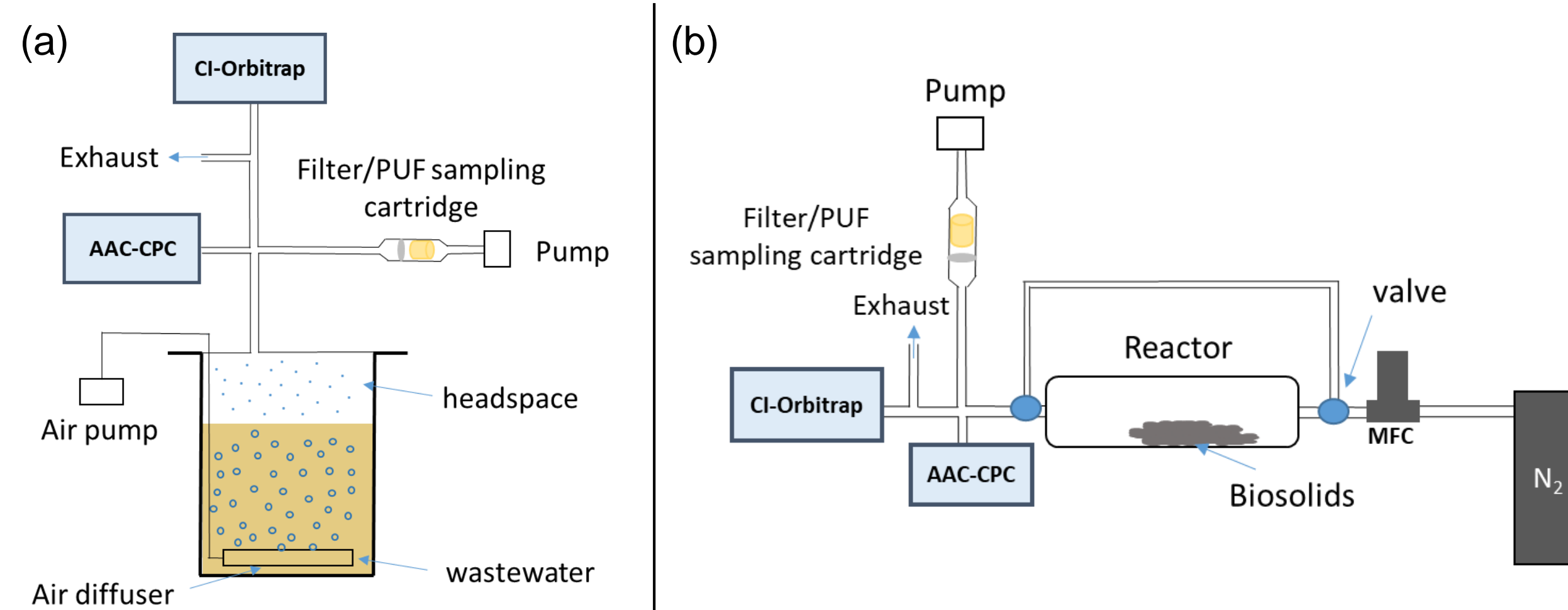


Figure 2. Experimental design of (a) laboratory-scale activated sludge reactor set-up and (b) Emission chamber

WP3: EC emissions in the real environment

WP3.1: ECs from aeration basin in WWTP (Headspace)

- On-line measurement (CI-MS, AAC-CPC)
- Active sampling (HVS -30m³/h)
- Wastewater sampling
- Summer and winter campaign (1 week)



WP3.2: Passive sampling (21 days of sampling)

- PAS-PUF (3 sampling period in winter and in summer):
- Headspace of aeration tank
- Few hundred meters downwind and upwind of basin
- In an agricultural field during biosolid spreading period



WP4: Atmospheric implication

- Evaluation of **aerosol size distribution**
- Identification of the most emitted ECs, that are the **key species to consider for air quality and climate impact evaluation**
- Evaluation of **gas-particle partitioning**
- Proposition of **tracers of aerosol emission** from WWTP activities
- Estimation of **fluxes and emission rates**

Preliminary field campaign

Passive sampling (PAS-PUF):

May 2024 – 21 days (n = 3)

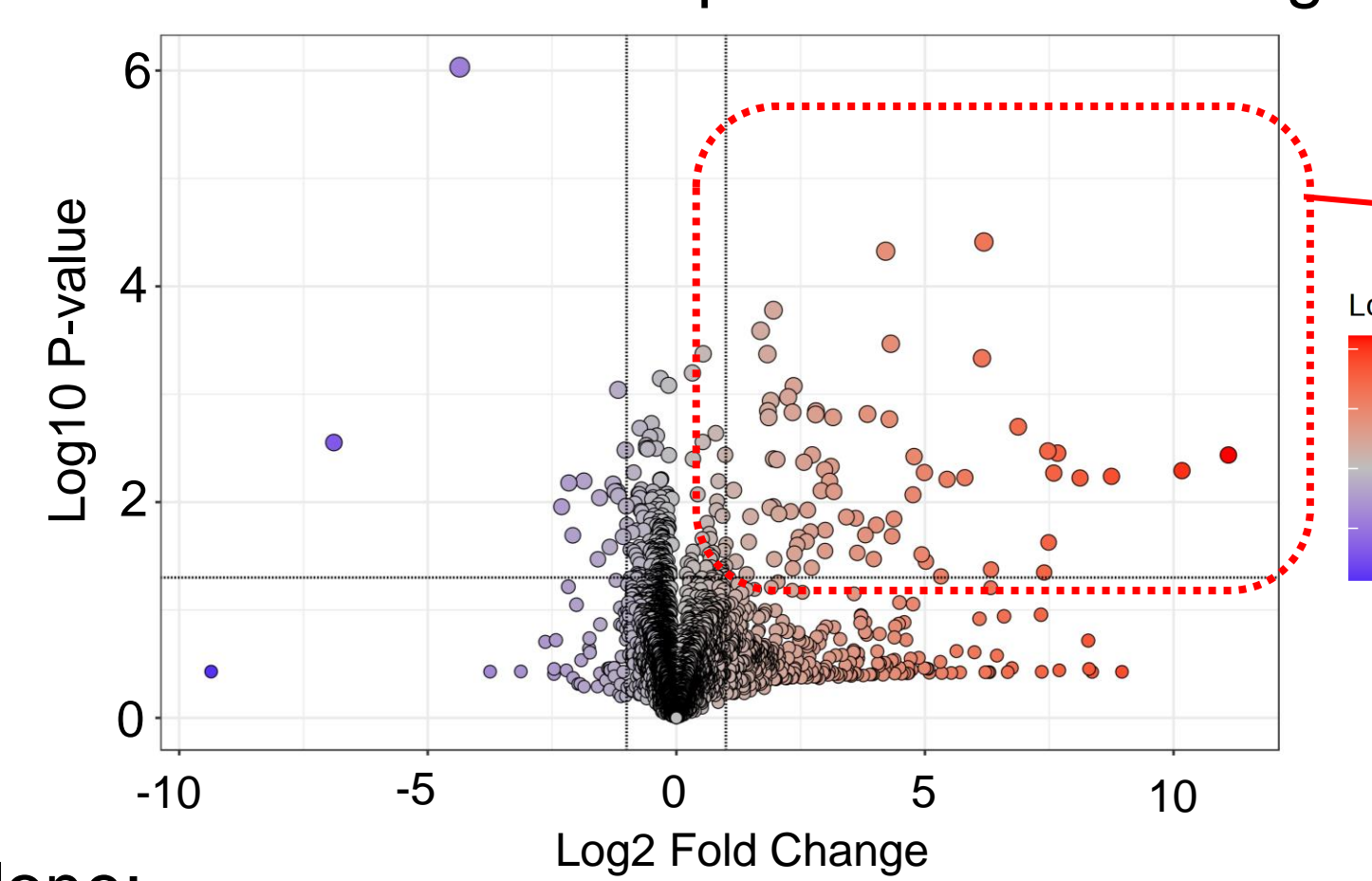
- (1) **Headspace of aeration tank (red)**
- (2) **At the boundary of WWTP site (green)**

✓ Double extraction assisted by ultrasound with methanol

✓ **Non-targeted differential analysis** with using **LC-HRMS** (Exploris 240, ThermoFischer)



Figure 3. Vulcano plot comparing data from Sites 1 and 2 – Injection in ESI positive mode using LC-HRMS



Interesting preliminary results:

Emission of chemical species from wastewater to the air?

Identification step in progress

To be done:

- High matrix effect with PUF: a purification step needs to be added during sample preparation to improve repeatability and sensibility.
- GC-MSMS injection is required to identify more volatile compounds, especially with the PUF samples
- A complementary sampling approach will be deployed, including active sampling (filter + PUF), passive sampling and on-line measurements.

Conclusion: The WECARE project aims to **significantly advance our understanding** of the **atmospheric implications** of **emerging contaminants emitted from wastewater treatment activities**. By integrating advanced analytical techniques, laboratory experiments, and field campaign, this project will provide new insights into the role of WWTPs as **sources of ECs** and their potential **effects on air quality and human health**.

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