Low energy treatment technology for leachate valorization - LIFE LEACHLESS

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Background

- In the EU, annually **16 tonnes** of materials are used by each person and **6 tonnes** of it are converted into waste.
- Solid waste can be disposed in **various ways**:
  - Incineration.
  - Landfilling.
  - Recycling.
  - Composting.

- **Landfilling has been the most commonly used solid waste disposal**, specially in the **Mediterranean and Eastern Europe countries**.
- Landfills present long-term threats to soil, air, groundwater and surface water due formation of greenhouse gases (methane gas and carbon dioxide from decomposing garbage) and **leachate**.

Leachate

- Leachate is the **liquid fraction** of the already existing moisture/liquid within the **solid waste** and the continuously formed liquid with dissolved and suspended solids extracted from the waste while rainfall percolates through it.
- Not only during their useful life, but also **fifty years after their closure**, landfills keep on producing leachate.
- Approximately, **10 m^3** of leachate is generated per **115 tonnes** of solid waste.
- The **composition** of leachate **differs** from site to site and also within the landfill, the composition of the leachate alters with time (from weeks to years).

Leachate

- The composition of the leachate depends on factors such as:
  - characteristics of the waste.
  - moisture content.
  - climatic conditions.
  - degree of compaction.
  - age of the landfill.

- Therefore, the leachate composition cannot be generalised and an unique treatment option cannot be suggested.

Leachate

- In the absence of treatment, leachate is:
  - Recycled back to the waste to maintain the biological activity in the composting solid waste by keeping it moist.
  - Send it to sewer or to a **wastewater treatment plant (WWTP) in case they do not treat it on site.**

Leachate treatment processes comparative costs (Source: Adapted from Giraldo, 2001)

Treatment technology	Cost (€/m^3)
Aerobic process with nitrogen removing	15.00
Two steps reverse osmosis	7.50
Biologic process + carbon activated + precipitation	18.75-26.25
Biologic process + reverse osmosis + concentrate evaporation	26.25-30.00
LIFE LEACHLESS technology (solar evaporation/condensation + forward osmosis)	**4.75**

LIFE LEACHLESS project

- LIFE LEACHLESS project demonstrates the **feasibility of an innovative in-situ treatment process** for leachates generated in landfills and waste treatment plants.
- The project LIFE LEACHLESS proposes a **sustainable management** composed of specially designed solar panels, which reach to very high temperatures to evaporate the leachate.
- Then the vapour is condensed to follow its path through **forward osmosis** (FO) step. FO requires less energy than the reverse osmosis (RO) and has less fouling problems.
- The project is **easy to replicate** and **easy to operate** and **maintain**.
- The proposed system is a **universal solution** independent of the leachate composition.

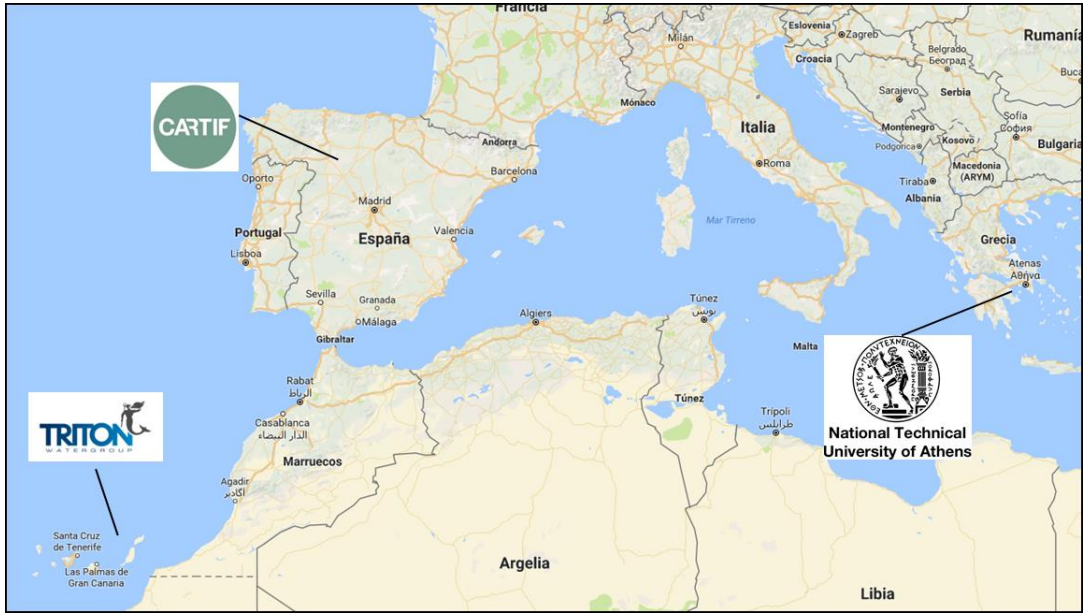
Main objectives

- The **LIFE LEACHLESS** project will promote water resources management actions in accordance with the **Water Framework Directive 2000/60/EC** by enabling managers of landfills and waste treatment centres to achieve good qualitative and quantitative status of their effluents.

- The LEACHLESS project proposes a **treatment model** that will be carried out **"in-situ"** using a **cost-effective** novel technology that combines **solar evaporation/condensation** plus **forward osmosis**. The prototype will be powered by **renewable energies** (solar energy, biomass and residual heat), which will minimise the **carbon footprint** of the process.

- The final effluent will be **reused** for **cleaning** and **gardening** purposes. A minority **semi-solid** residual **stream** will be also generated in the process. Due to its special composition (rich in metals and inorganic elements), this stream will be **valorised** in ceramic industries to improve the final products characteristics.

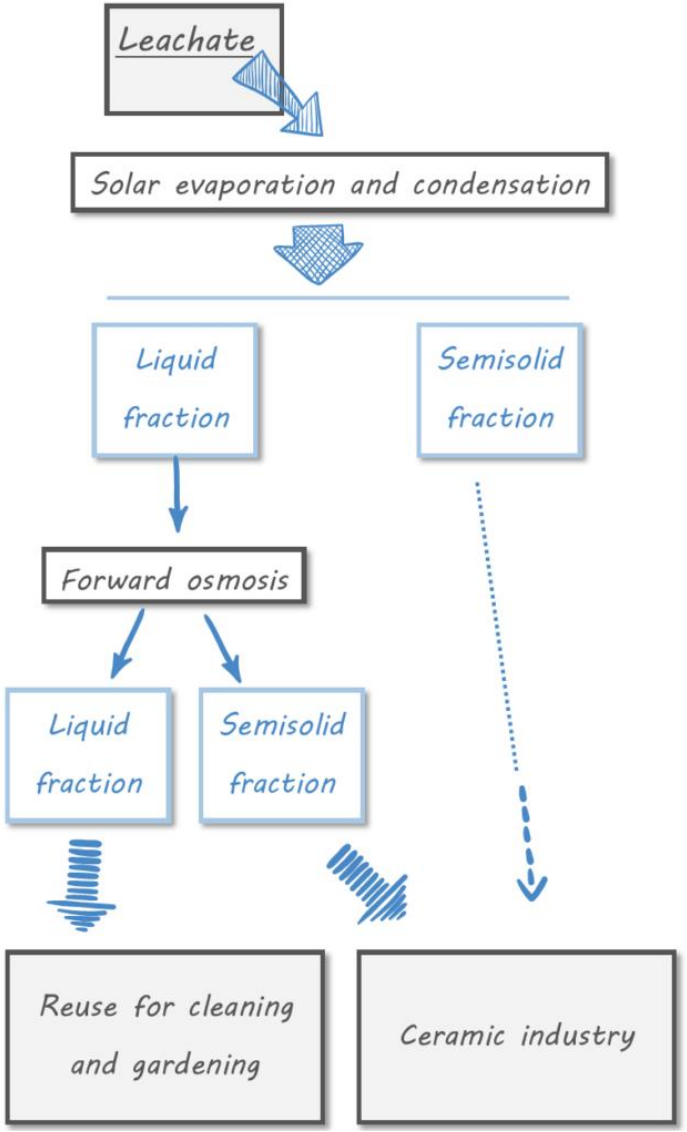
The figures of the project



LIFE 15 ENV/ES/00530

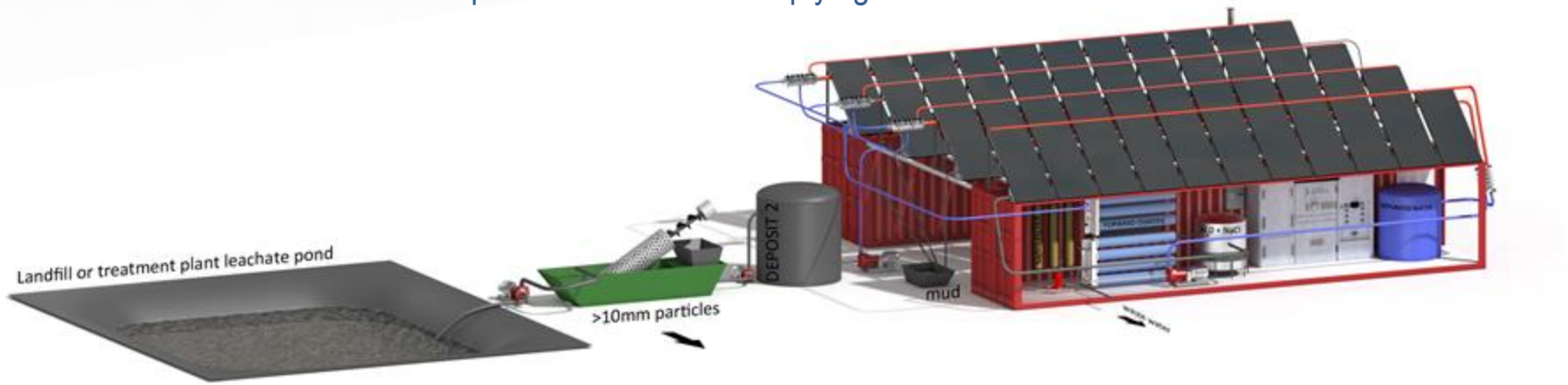
Dates	Start: 01/10/2016	**Figures**	Total budget: 1,775,805 €
	End: 31/12/2020		EU contribution: 1,041,237 € (60% of eligible budget)
	Extension: 30/06/2023		3 partners

Process diagram



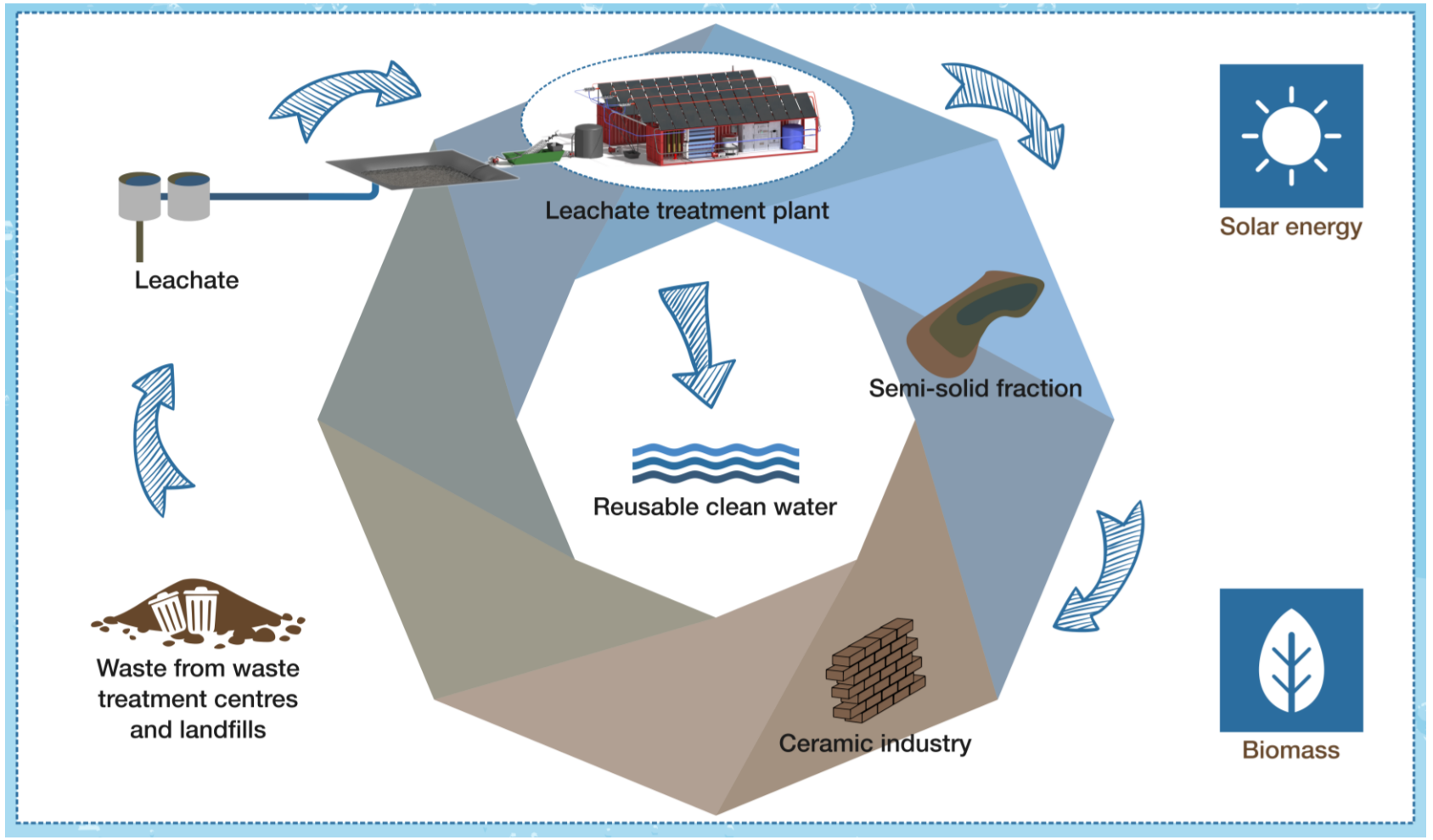
LIFE LEACHLESS prototype

- The proposed treatment system is composed of two main separation processes:
  - a **novel solar panel**, which evaporates and condenses the leachate in the first step.
  - **forward osmosis** step to obtain effluent complying with the reuse standards.



- This system will be placed in three containers (12mx2,4mx2,9m), for the easy portability between the demonstrations sites:
  - a **waste treatment centre** in Spain.
  - a **landfill** in Greece.
- The maximum **capacity** of the plant is **12-8 m^3/day**.

LIFE LEACHLESS project and circular economy philosophy



Results

- Prior to the construction of the demonstration plant, **laboratory-scale tests** were carried out with the two technologies.
  - Solar evaporation/condensation.
  - Forward-osmosis
- The aim was to optimise the **operating conditions** of the individual treatment processes.
- The results served as the basis for the **design** of the demonstration plant.

Results

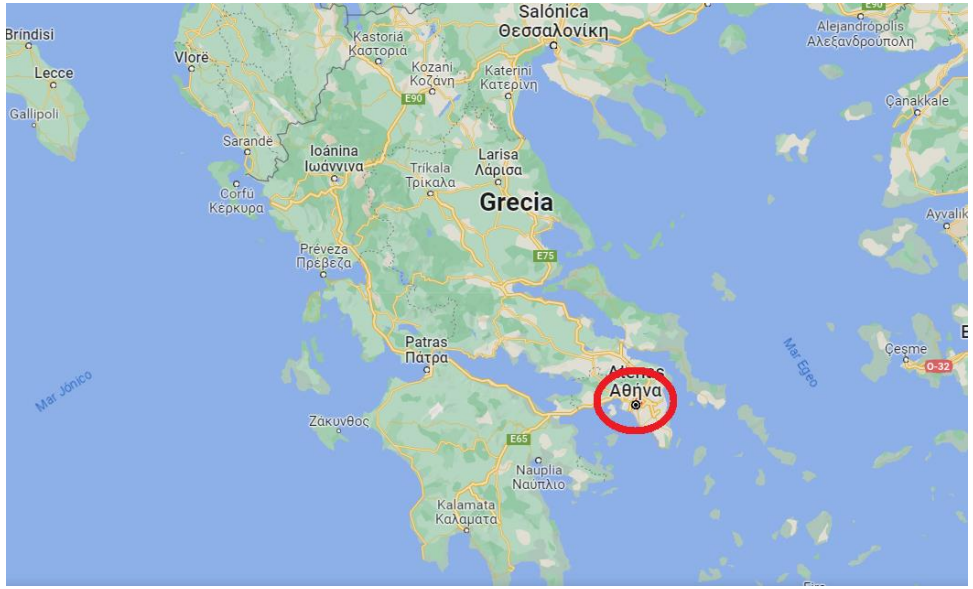
- After the lab-scale tests, the **construction of the demonstration plant** was carried out.
- The plant has been operated at **two demo sites.**

Results

- First demo site: Waste Treatment Centre in Lanzarote (Spain)

Results

- Second demo site: Ano Liosia landfill in Athens (Greece)



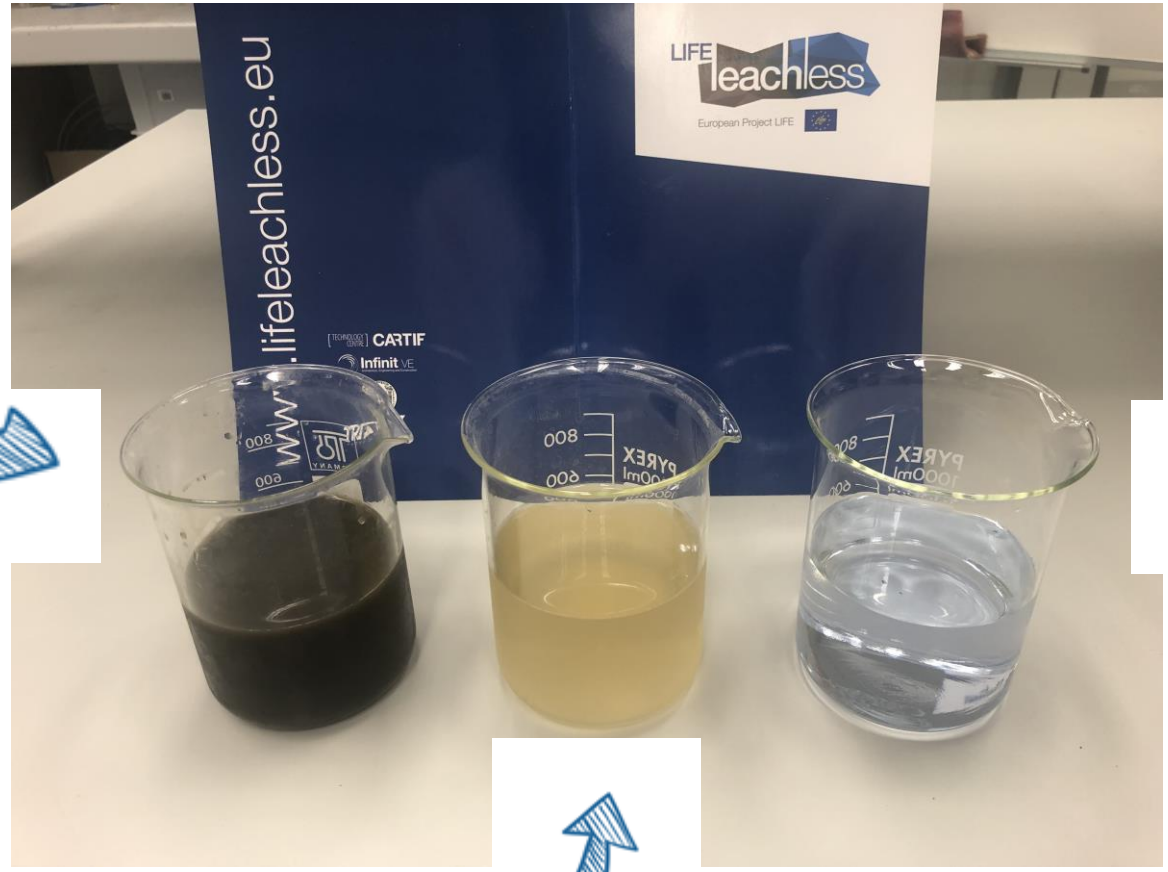
Results

- Results of the leachate treatment system from the demonstration plant:

Physicochemical parameters	Unit	Initial leachate	Final effluent	Limit value
BOD_5	mg/L O_2	7,160	17	< 25
COD	mg/L O_2	13,850	51	< 125
Suspended solids	mg/L	1,820	1	< 2
Conductivity (20ºC)	µS/cm	31,100	787	700-1,000
Total phosphorus	mg/L	182	2.63	< 10
Intestinal nematodes	eggs/L	<1	<1	< 1
Escherichia coli	cfu/100 mL	3,158	1	≤ 50
Volatile suspended solids	mg/L	1,440	5	< 20
Copper	mg/L	0.2	<0.01	< 0.1
Iron	mg/L	153.76	<0.01	< 2
Sodium	mg/L	2770.1	18.7	< 70
Aluminium	mg/L	531.74	<0.01	< 1
Arsenic	mg/L	0.5	0.05	< 0.05
Barium	mg/L	0.2	0.02	< 20
Cadmium	mg/L	0.2	0.002	< 0.005
Chromium	mg/L	0.29	0.07	< 0.1
Tin	mg/L	0.3	0.03	< 10
Manganese	mg/L	0.2	0.02	0.5
Nickel	mg/L	0.31	0.03	< 0.05
Lead	mg/L	0.2	0.04	< 0.05
Zinc	mg/L	0.74	0.05	< 0.5
a-HCH	µg/L	0.01	0.01	< 0.05
Endrin cetona	µg/L	0.01	0.01	< 0.05
Heptaclor	µg/L	0.01	0.01	< 0.05
Heptaclor epóxido	µg/L	0.01	0.01	< 0.05
Lindano	µg/L	0.01	0.01	< 0.05
p,p'-DDD	µg/L	0.01	0.01	< 0.05
p,p'-DDE	µg/L	0.01	0.01	< 0.05
p,p'-DDY	µg/L	0.01	0.01	< 0.05
Aldrín	µg/L	0.01	0.01	< 0.05
b-HCH	µg/L	0.01	0.01	< 0.05
d-HCH	µg/L	0.01	0.01	< 0.05
Dieldrín	µg/L	0.01	0.01	< 0.05
Endosulfan I	µg/L	0.01	0.01	< 0.05
Endosulfan II	µg/L	0.01	0.01	< 0.05
Endosulfan sulfato	µg/L	0.01	0.01	< 0.05
Endrin	µg/L	0.01	0.01	< 0.05

Results

- Samples from the demonstration plant operation in Lanzarote:



Initial leachate

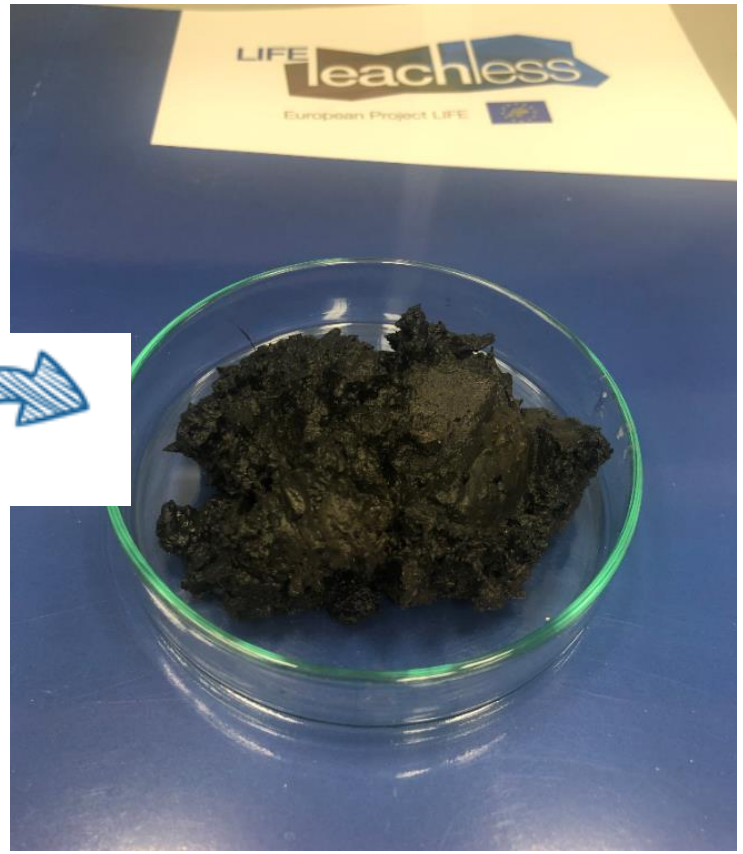
Final effluent

Effluent after evaporation/condensation

Results

- Samples from the demonstration plant operation in Lanzarote:

Sludge (by-product)



Results

- All parameter **concentrations** have been considerably **reduced**.
  - COD reduction of 99%.
  - Very low metal concentrations.
  - Reduction of sodium concentration of 98%

Conclusions

- **Optimisation** of operating and process conditions for solar evaporation/condensation and forward osmosis.
- Aquaporin™ **hollow fiber membrane** selected for forward osmosis process.
- Recovery of up to **80-70%** of the leachate (the remainder is recovered as sludge or reused in the drawn solution).
- **Quality** of the final effluent according to the limits established by **legislation**.
- **Sludge** obtained as a by-product with an interesting metallic composition to be used in the formulation of **ceramic components**.

Thank you for your attention

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