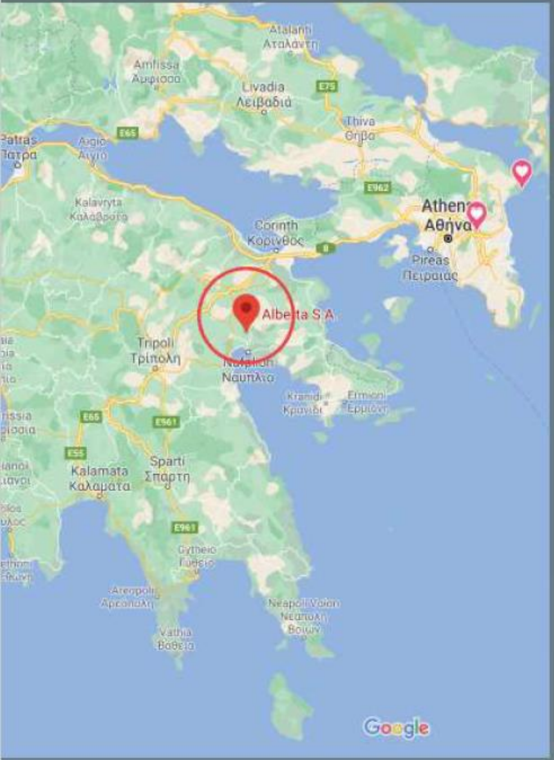
ULTIMATE

indUstry water-utiLiTy symbiosis for a sMarter wATEr society

The project leading to this application has received funding form the European Union's Horizon 2020 innovation programme under grant agreement No 869318

Case Study 4

- Fruit processing industry
- Nafplio, Eastern Peloponese, Greece
- High water demand puts pressure in the aquifer
- Seasonality puts strain on the local biological treatment plant
- Under-performing biological treatment plant, leads to higher waste removal cost



Goals

The Unit

Recovery of Value-added compounds

AOP

SBP

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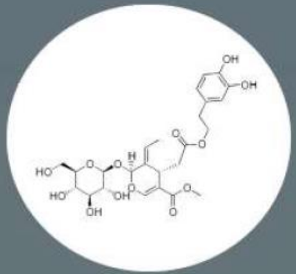
Case Study 4 Goals

- Treat individual & final waste streams

- Isolate useful/value-added compounds compounds (properties & market price) e.g. polyphenols, flavonoids, anthocynins etc

- Treat wastewater so it can be recycled:
  - **Irrigation of nearby orchards**
  - Reused within the plant for secondary uses or reduce the organic load sufficiently so the biological treatment plant can cope



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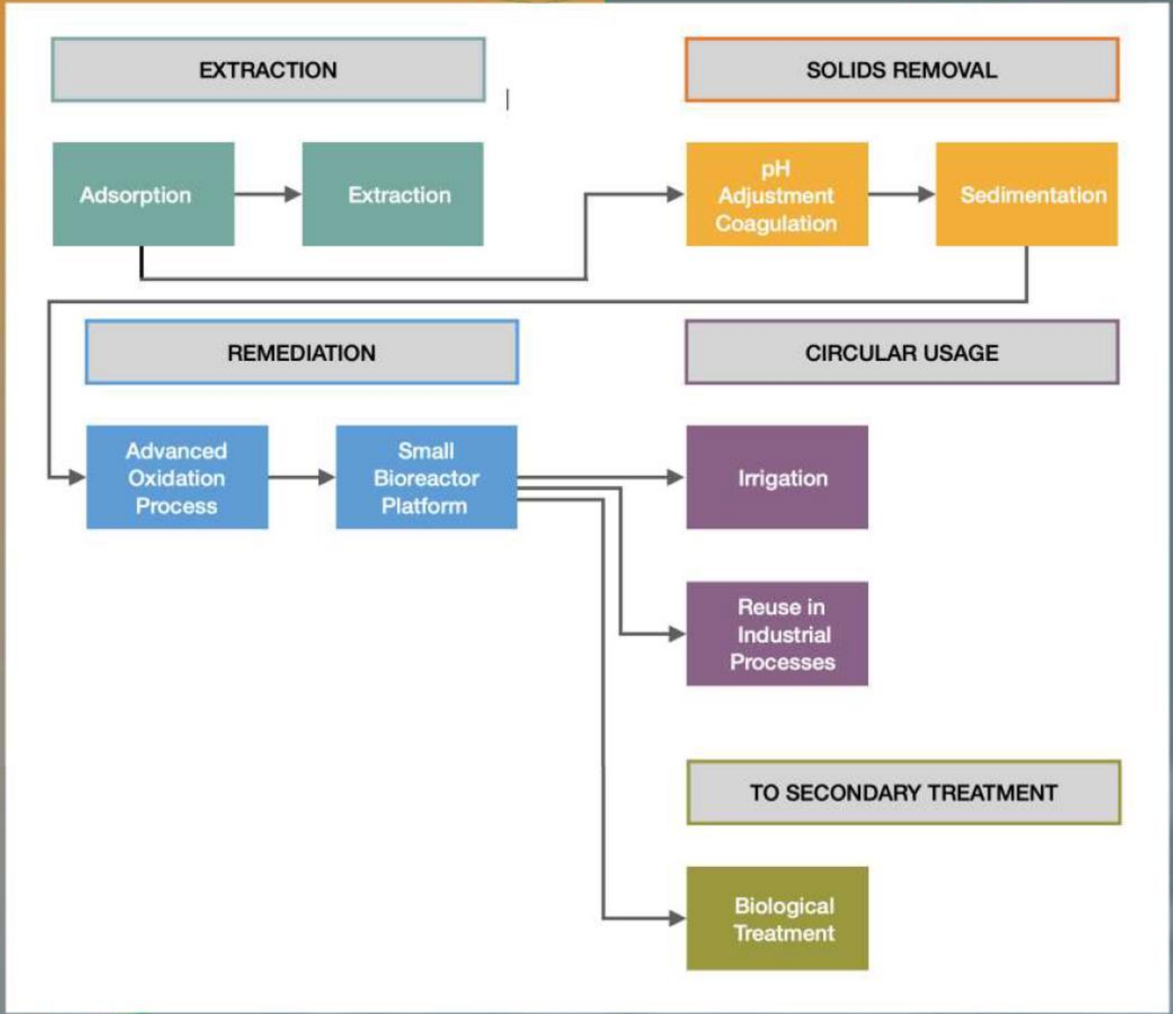
Unit Design

Cross-section

P&ID



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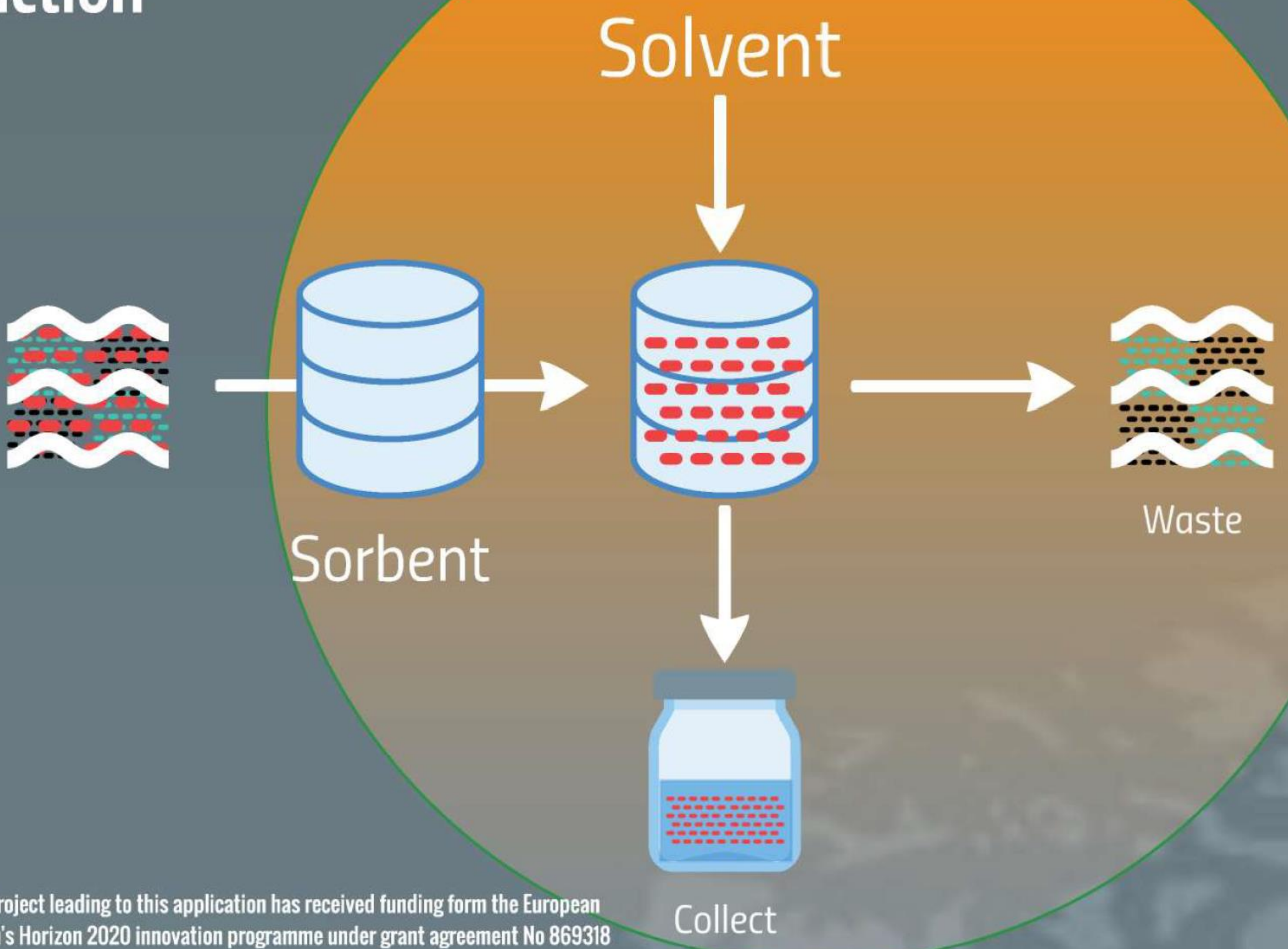
Value-Added Compound Extraction



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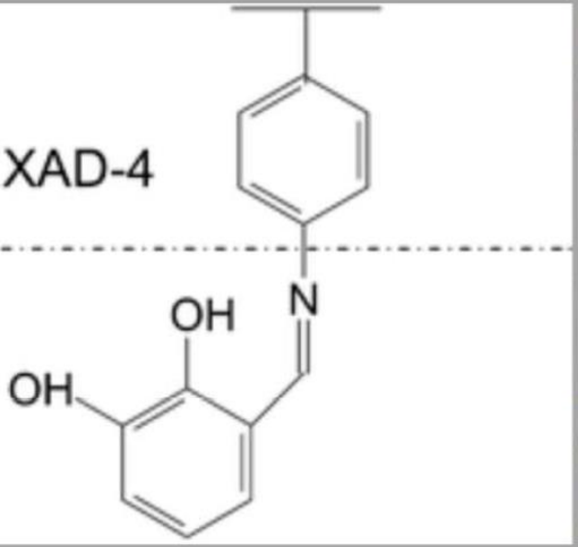
Adsorption considerations

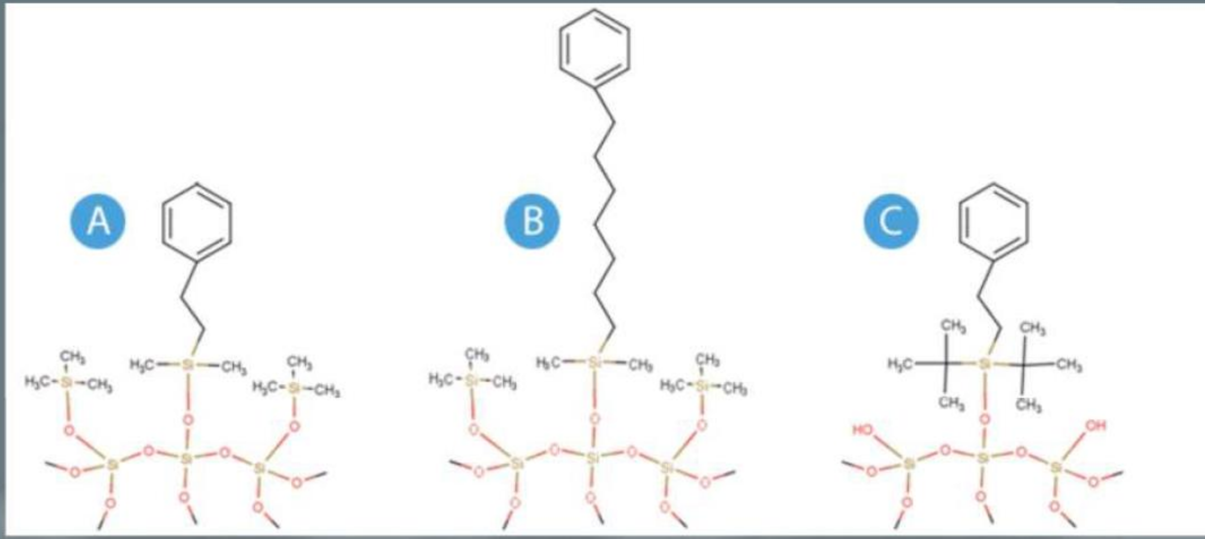
Selectivity	Hydrophobicity/ Hydrophilicity bias	Materials
preferentially bind a specific class of compounds	retain also almost hydrophobic compounds	

Sorbents

Beyond

Adsorbent	Material	Structure	Particle size (µm)	Surface Area (m^2/g)	Pore Size (Å)
AmberLite™ FPX66	Resin	Aromatic	700	800	150
AmberLite™ XAD-4	Resin	Aromatic	640	750	100
Phenyl-Hexyl	Silica	Aromatic	15	400	100





Biosorbents

agro-industrial solid wastes can be used as sorbents

- cheap
- eco-friendly
- upcycling
- waste reduction

Recovery

Recovery attributes

- Efficiency
- Environmental hazards
- Cost effectiveness
-
- Ease

Extraction Solvents

Subcritical Water Extraction

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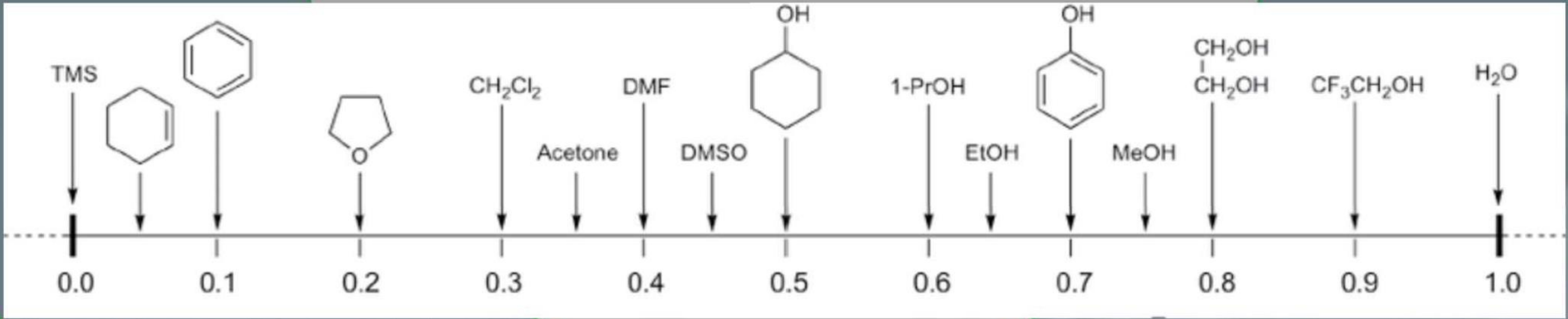
Extraction Solvents

Water - cheap, inefficient, non-toxic
Methanol - high cost, increased toxicity
Ethanol - very high cost, lower toxicity



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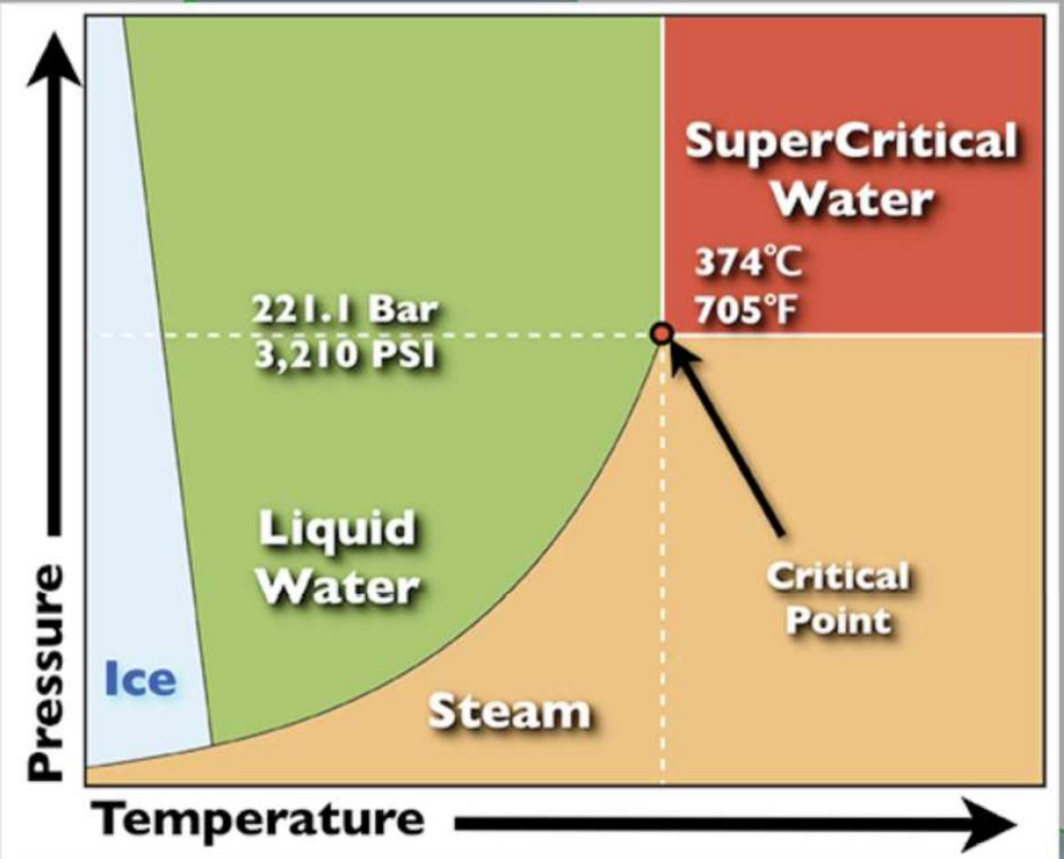
SubCritical Water Extraction (SCWE)

- Temperature: 100 - 374°C
- Pressure high enough to be in the liquid phase 10-20 bar



- Efficiency
- Low cost
- Non-hazardous - green

Value-Added Compounds

Polyphenols:

- Naturally occurring compounds
- Complex structures containing multiple phenolic rings
- Two main classes **phenolic alcohols**, **phenolic acids**
- Further classification depending on the phenolic ring strength (phenolic acids, flavonoids, stiblins, phenolic alcohols, and lignans)

Structures

Examples

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Results

Static Adsorption

Dynamic Adsorption

Recovery

Static Adsorption Methodology

Static Adsorption Results

Dynamic Adsorption Methodology

Dynamic Adsorption Results

Recovery

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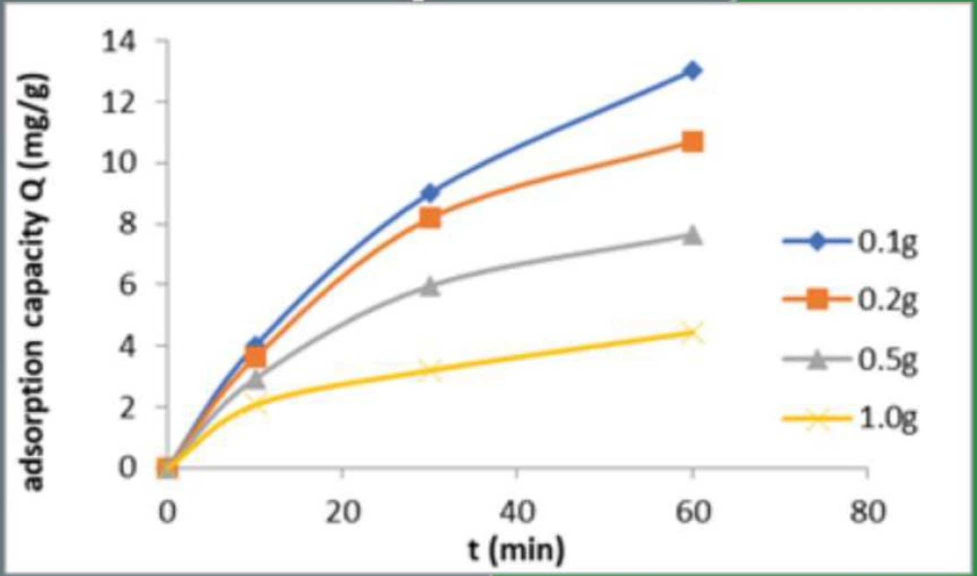
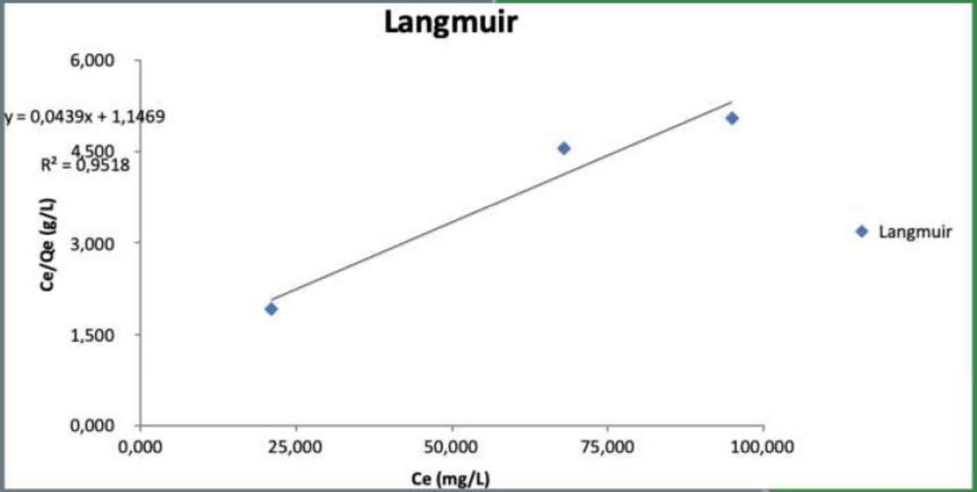
Static Adsorption Results





Maximum capacity 22,78 g/kg
(g of polyphenol per kg of resin)

Contact time vs Adsorption %

60 min 95%

30 min 60%

Yield = 130 g/m3
(mg of polyphenol per L of wastewater)

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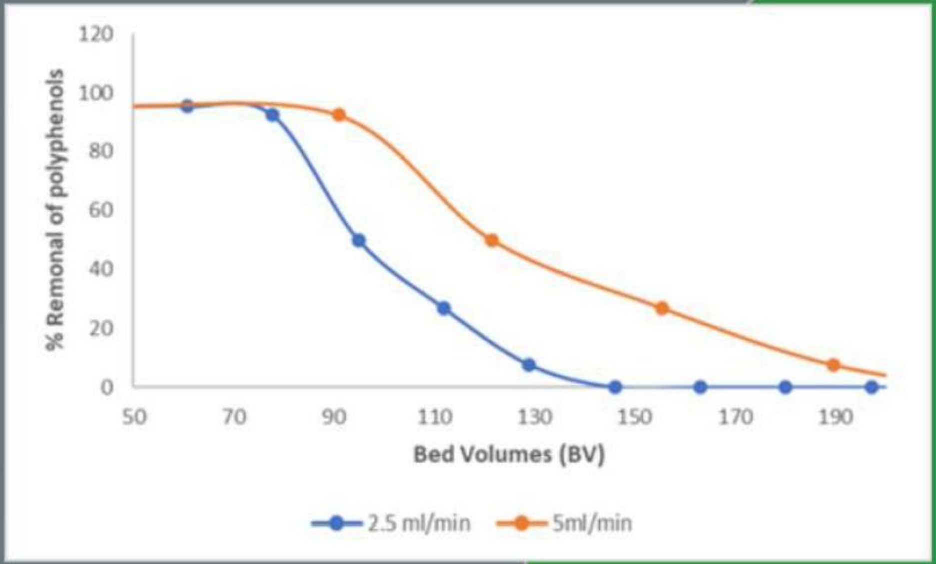
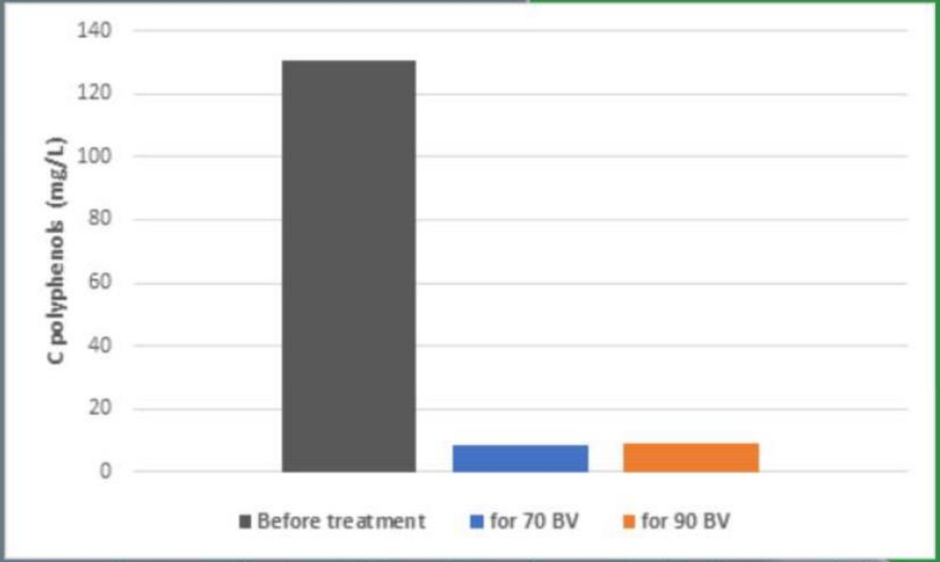
Dynamic Adsorption Results





Unit

- The adsorbent is capable of adsorbing polyphenols for at least 10 regeneration cycles
- 1.7 m^3 wastewater can be treated per kg of resin per cycle

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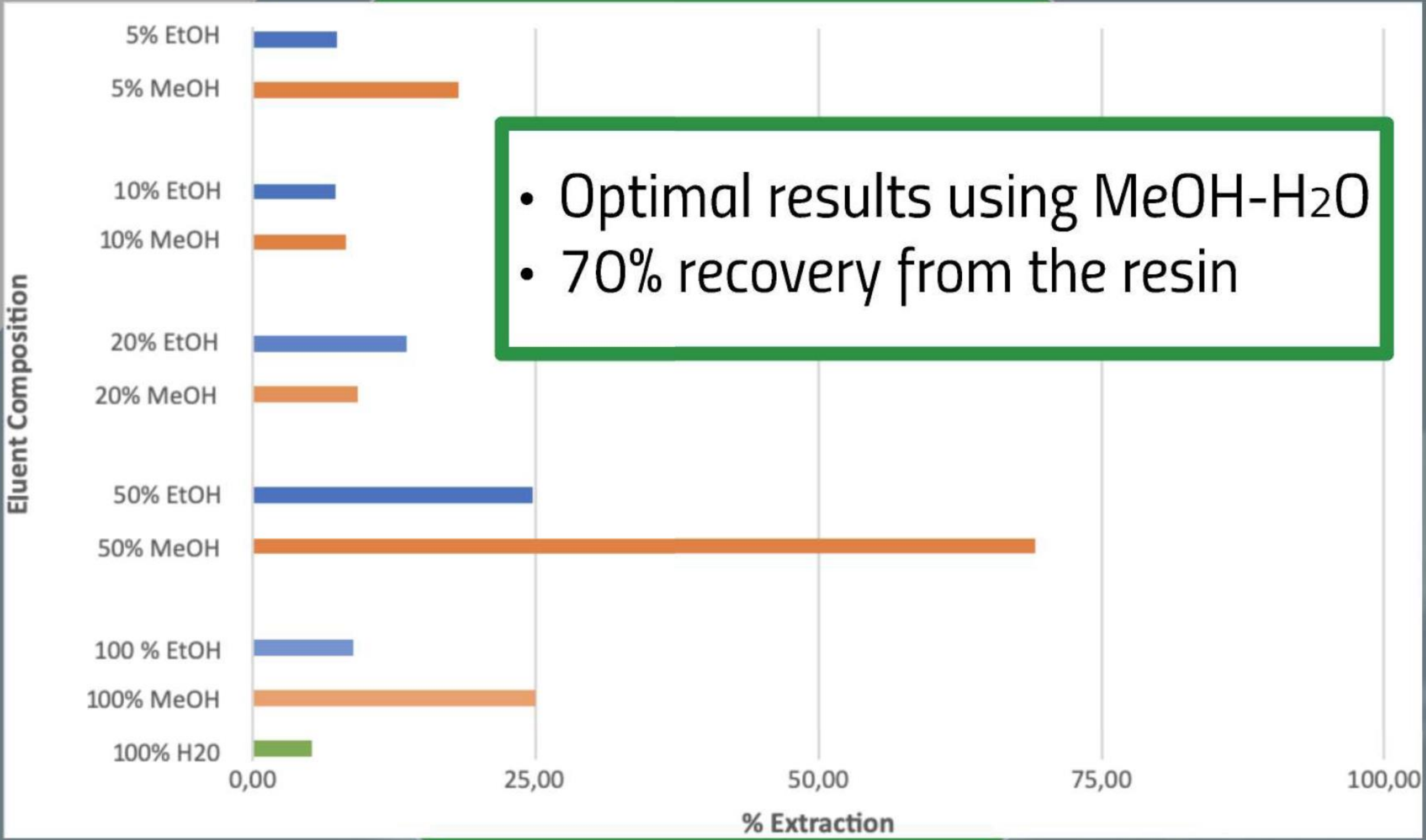
Pilot Plant Adsorption Results

- Continius flow dynamic adsorption adsorbes over 80% of the polyphenols present in orange juice by-product

- This step has 20% contribution in the reduction of the overall Total Organic Carbon (TOC) of the orange juice by-product

Recovery



- Optimal results using MeOH-H_2O
- 70% recovery from the resin

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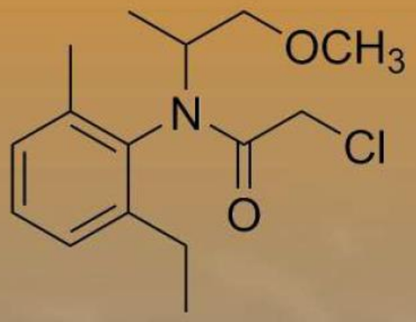
Advanced Oxidation Process

Catalyst
or
Oxidant

+UV

$OH^{\bullet}$

Hydroxyl
radical



Pollutant

CO_2

Design

Model
Compound
Selection

Results

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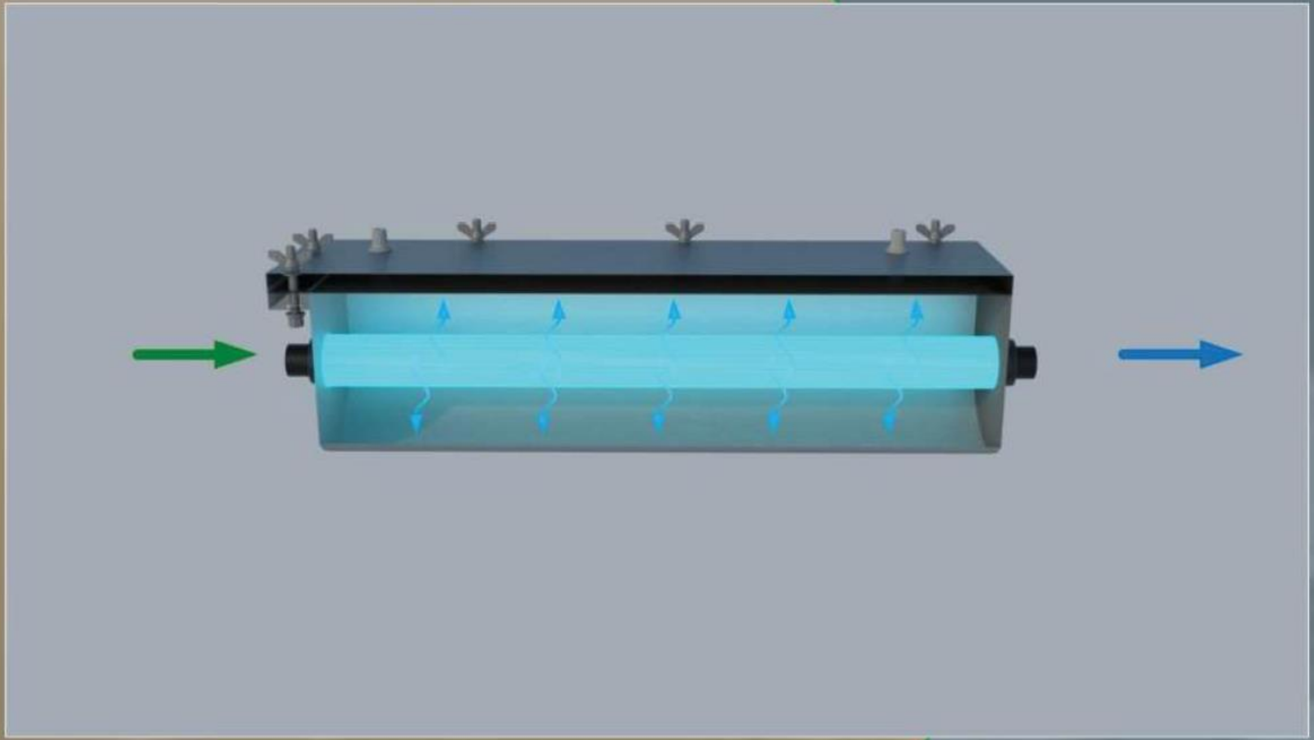
The CPC photocatalytic reactor

Annular

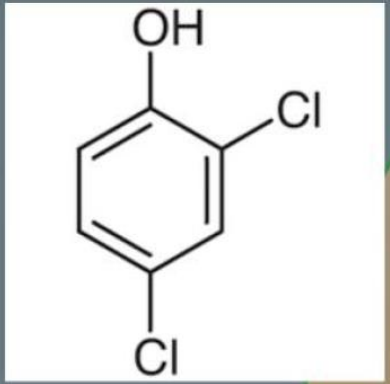
- Continuous flow
- Operates under either solar or artificial UV light

The annular photocatalytic reactor



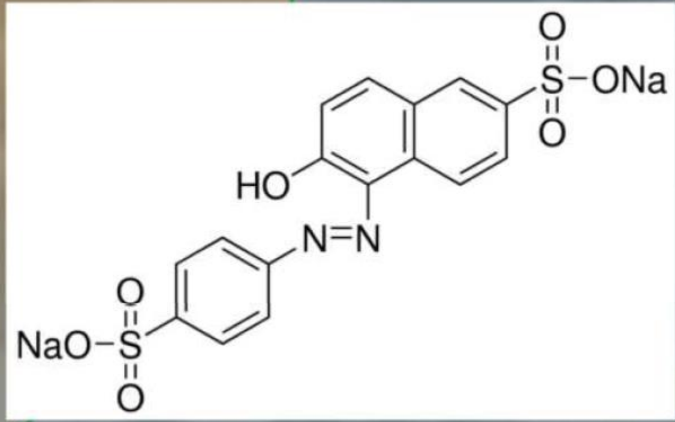
- Continuous flow
- Operates under artificial UV light

Model Compound Selection

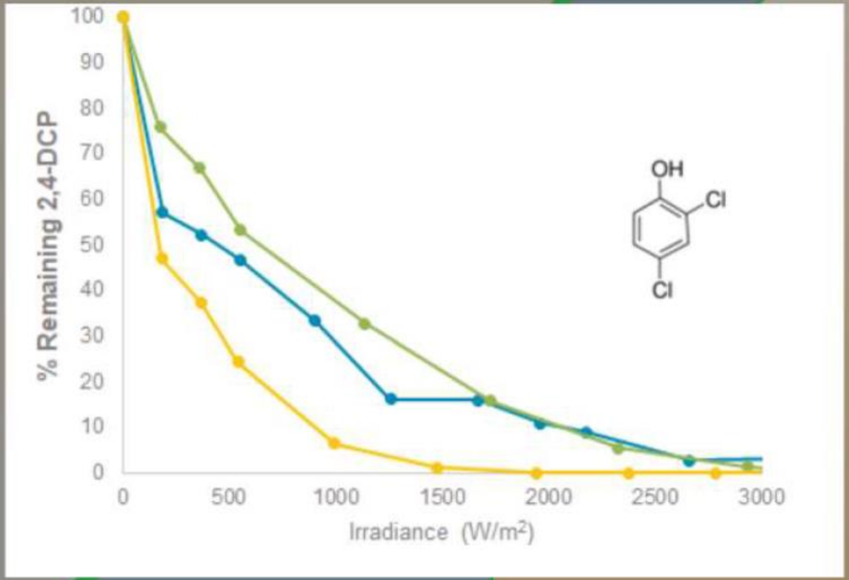


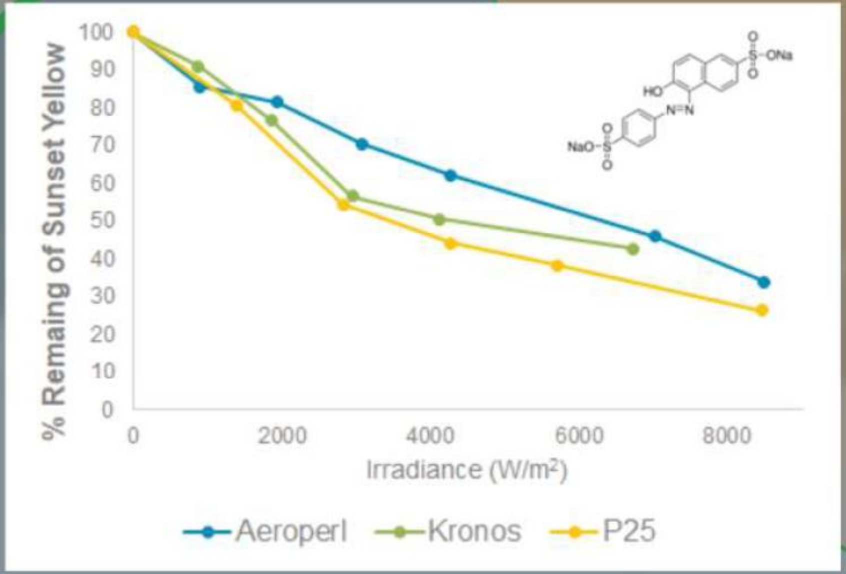
Lab tests:
2,4-Dichlorophenol

Pilot scale tests:
Sunset Yellow

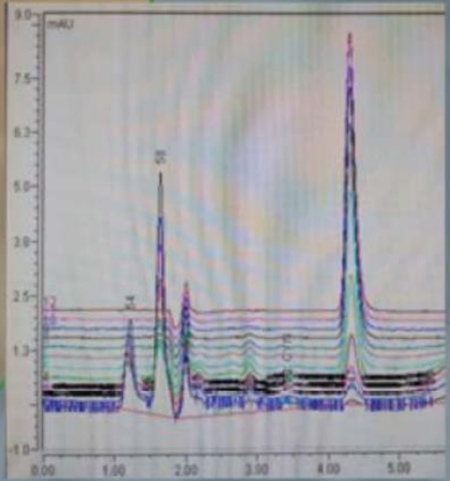


Degradation of model compounds





Demonstrated ability to remove 90% of organic pollutants



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