SMAR3TS

Staff Mobility to Action Resilient, Restorative, and Regenerative Transitions & Societies

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Innovate3X at UPC BarcelonaTech

Research Center in Multiscale Science and Engineering (CCEM), Spain

Research Group: Resource Recovery and Environmental Management (R2EM)

Presented by: Prof. Jose Luis Cortina Pallás (UPC BarcelonaTech)

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Introduction

- **Leader of R2EM Research Group** at UPC BarcelonaTech
- **Researcher** at the Multiscale Science and Engineering Research Center (MSERC) and the Hydrogen Research Center (CER-H2), and a **professor** in the Department of Chemical Engineering at the Barcelona School of Engineering East (EEBE)
- Scientific career spans the **fields of Chemical, Industrial, and Environmental Engineering**
- **Technical scientific advisor** at the Water Technology Center (Cetaqua) that promotes decarbonization solutions
- Held a **two-year NATO** postdoctoral **research** position in the field of Fiber Optic Chemical Sensors at the Center for Industrial Process Control (University of Washington, US)
- **Working with waste processing technologies to ensure a secure, circular, and sustainable supply of critical raw materials (e.g., metals for electric vehicle batteries or electronic components) through urban and industrial mining approaches**.
- Supervised around **30 doctoral theses** and has been the **Principal Investigator** on more than 20 national and **EU-projects**.
- Co-author of more than 300 JCR-indexed publications.

Professor Jose Luis Cortina

Skills and Expertise:

- Remediation
- Water and Wastewater Treatment
- Adsorption, Sorption, Desalination
- Membranes
- Water Purification Technologies
- Wastewater Engineering
- Membrane Technology
- Membrane Separation

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R2EM Research Group is part of CCEM

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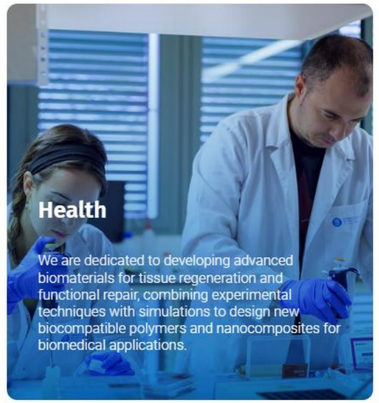

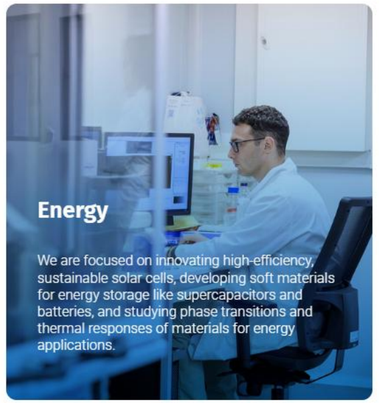

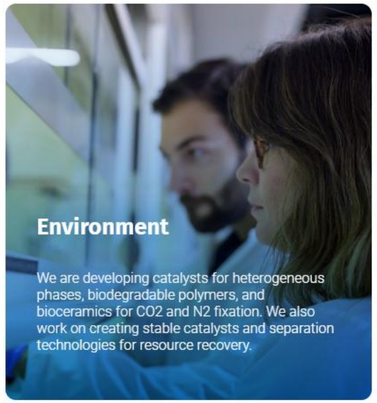

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Research Center in Multiscale Science and Engineering (CCEM)

SMAR3TS

31,5 million €
Of competitive funding

3,3 million €
In tech transfer agreements
With several companies worldwide

+1000
Publications
In the most prestigious journals

19
EU-funded projects
In collaboration with key research centers and universities

4
ERC projects
Granted in recognition to our cutting-edge research

250
Scientists
From interdisciplinary backgrounds

8
Research groups
In the fields of energy, health and the environment

45%
Of women researchers
Promoting our compromise with equality

Biomaterials, Biomechanics and Tissue Engineering (BBT)

Structural Integrity and Materials Reliability Centre (CIEFMA)

Group of Characterization of Materials (GCM)

Innovation in Materials and Molecular Engineering (IMEM)

Micro and Nanotechnologies - Photovoltaic laboratory (MNT-Solar)

Nanoengineering of Materials Applied to Energy (NEMEN)

Biodegradable and Ecologic Polymers and Composites (eb-POLICOM)

Resource Recovery and Environmental Management (R2EM)

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Resource Recovery and Environmental Management (R2EM) Research Group

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Research & Development – Key areas:

- **Innovation processes** for metal recovery, pollutant removal, and environmental monitoring
- Work with **separation technologies**
- Development of analytical, waste characterization and treatment methods to **minimize environmental impact**

Picture source: R2EM
https://multiscale.upc.edu/en/research/r2em/laboratory-of-organic-solar-cells

Research field: Environmental sciences and technologies

- Development of separation processes for metal recovery and pollutant removal using adsorption, biopolymers, reactive resins, and membrane technologies.
- Validation of analytical methods and sensors for monitoring industrial and environmental contaminants, including dissolved organochlorine compounds and volatile organic pollutants.
- Characterization and treatment of industrial and nuclear waste, including pollutant behavior modeling and risk assessment.
- Development of technologies for restoring contaminated soils and aquifers, with a focus on environmental and human health impact.

R&I infrastructure in the lab:

- advanced facilities for adsorption and membrane-based separation processes
- chromatographic and electrophoresis systems
- chemical sensor development technologies

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Research domains

Resource-factories and water reclamation

Transformation of wastewater treatment plants into resource recovery facilities

Industrial and Urban Mining (Critical Raw Materials)

Recovery of critical raw materials from industrial tailings, e-waste and other urban waste streams

Seawater mining (Blue economy)

Recovery of minerals from seawater/brines/salt works

Bio-based economy

Turn renewable biological resources into products (food, energy, materials…)

Circular Process Engineering and Industrial Symbiosis

Integration of business opportunities for an industrial ecosystem that leverages underutilized resources (energy, water, materials, assets…)

Circularity and Sustainability Assessment

Quantifying sustainability and circularity of proposed technological solutions by integrating a portfolio of methods and tools

Specific services:

- Studies to evaluate risk to human health and ecosystems
- Evaluation of new materials to treat water polluted by metals
- Evaluation of new materials for recovering metals from liquid effluent
- Development of methods for the chemical analysis of pollutants

Relevant equipment:

- Atomic absorption
- HPLC
- UV-Vis spectometry
- Surface area determination
- Cooperation with the CTM, ICP-MS, GC-MS, TOC, FT-IR
- Laser spectroscopy

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Knowledge, skills and capabilities (TRL 3-5)

Separation processes, membrane technologies, technologies integration, circular processing, digital tools for process design and optimization

Membrane Technologies: MF, UF, NF, RO, ED, SED, EDBP, DD, MD, LLMC
Sorption and Ion Exchange Technologies
Digital tools development: process design and integration

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Knowledge, skills and capabilities (TRL 3-5)

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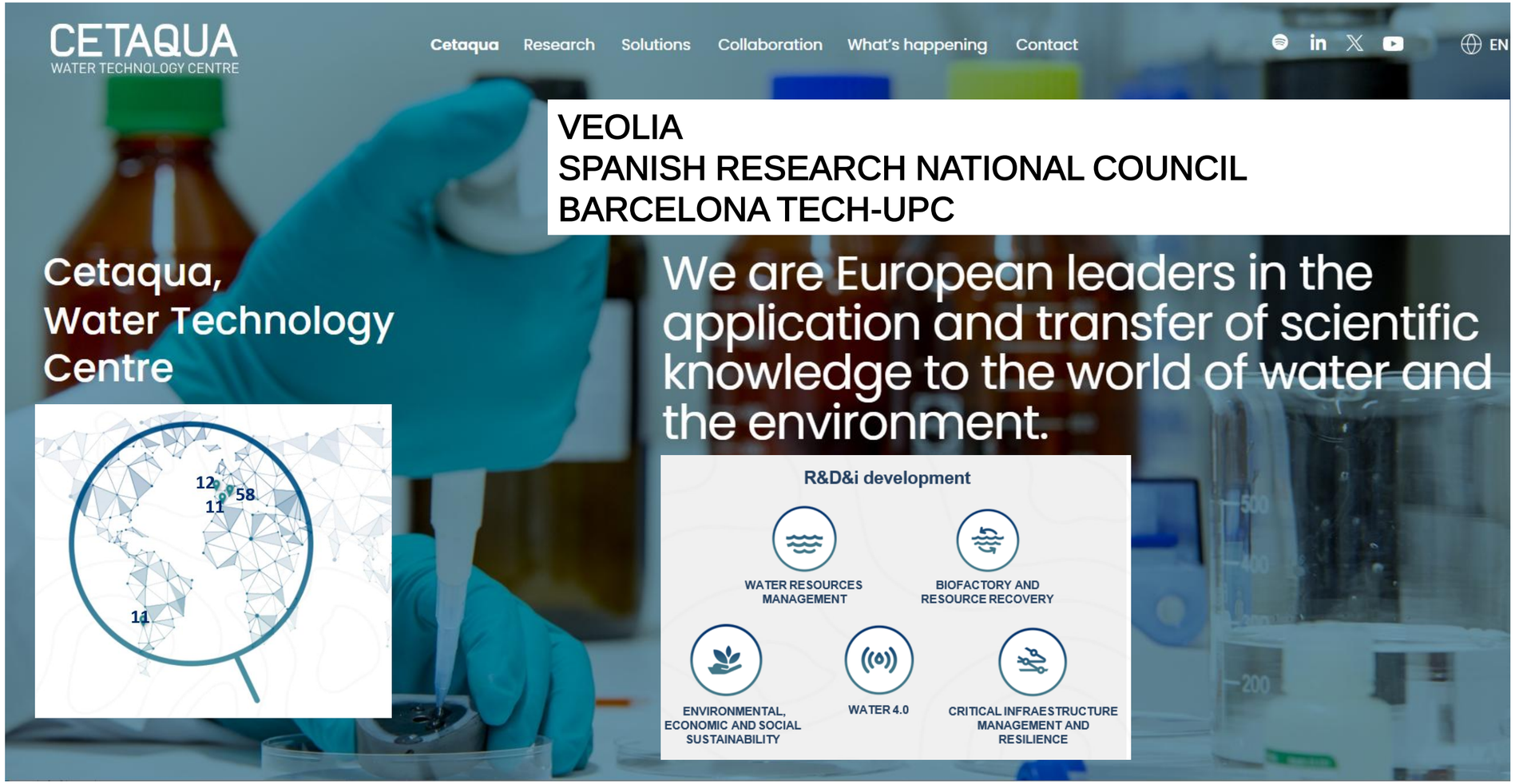
RDI partnership with Industrial technology partners



(TRL 7-9)

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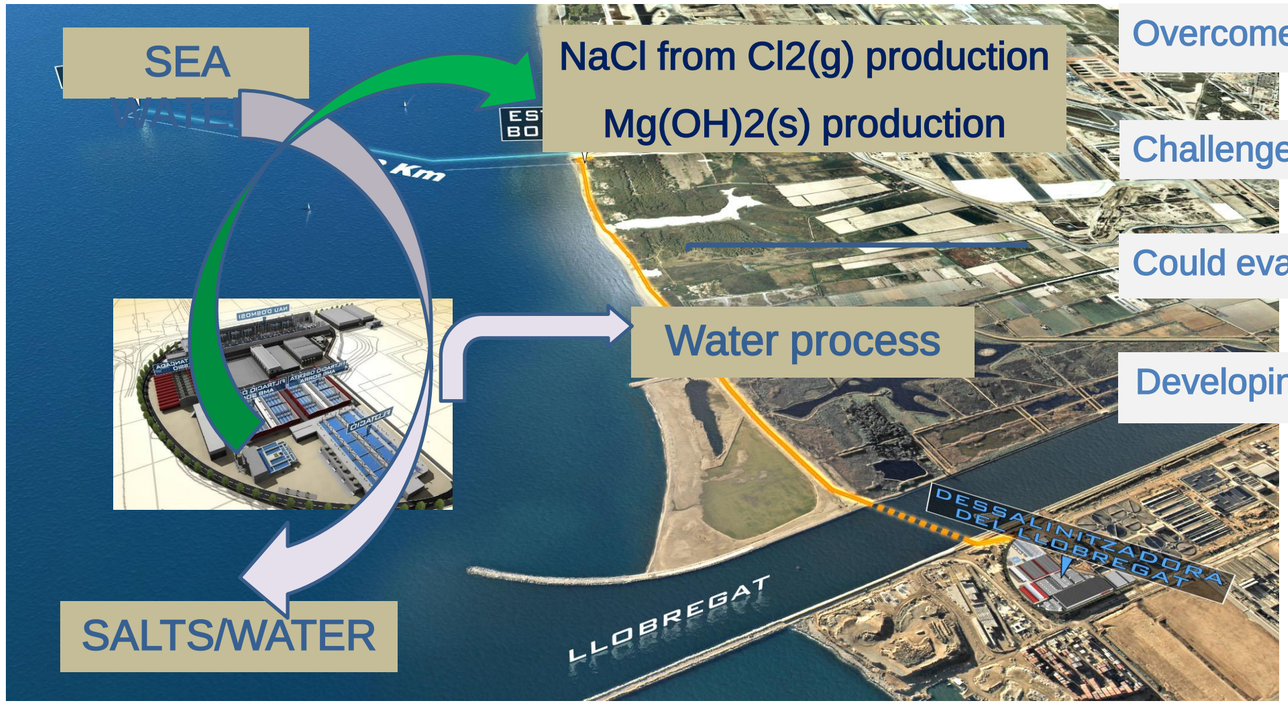
Examples of current R&I work

Industrial Feasibility of brine mining for $Cl_2(g)$ and $Mg(OH)_2(s)$ production

Industrial site (close to sea): water and minerals chemical producer



- Overcome the large salt vacuum transport emissions (decarbonization)
- Challenge: substitution of vacuum salt by high quality NaCl brine
- Could evaporation/crystallization be avoided? (process decarbonization)
- Developing a business case for a chemical company (0.5 Mt/y) in Europe (Spain)

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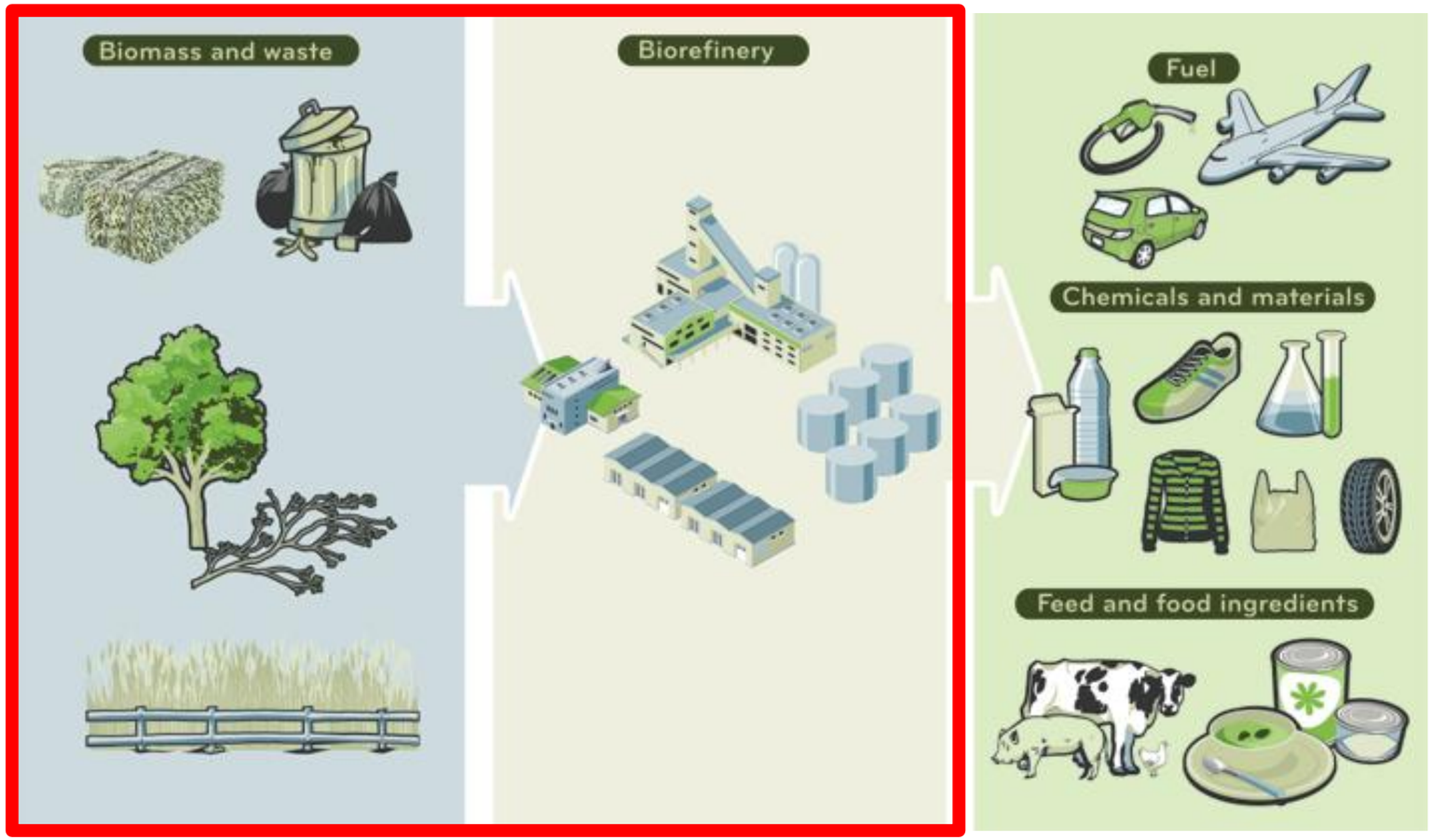
Examples of current R&I work

Bio-based economy: Upcycling of agri-food waste (Biofactory Concept)



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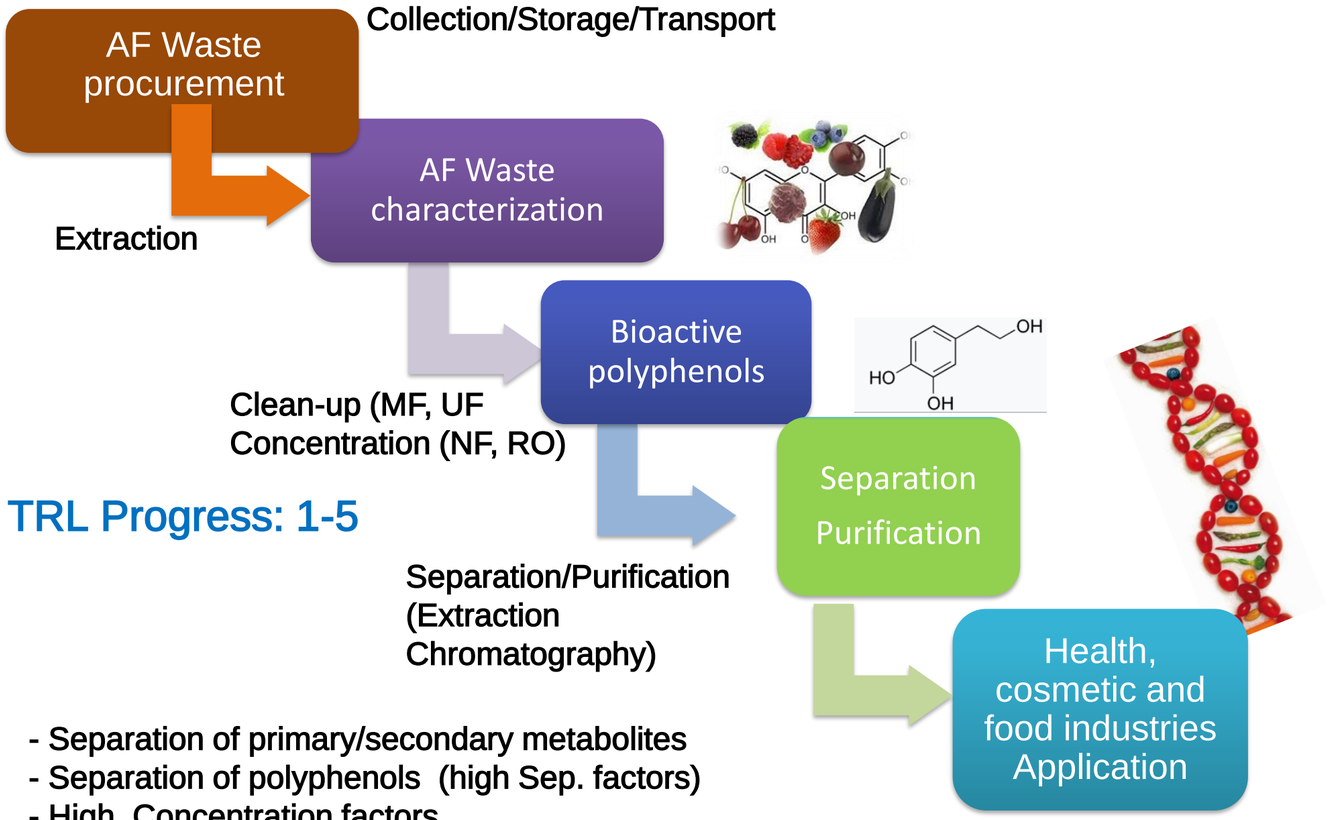
Examples of current R&I work

Domain Bio-based Economy. Building the value chain for antioxidants production



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Examples of current R&I work

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UPCYCLING PROJECT

SECONDARY RESOURCES (SR)

Agri-food (SR1)

Fruits Vegetable Fish Meat

Process Industry Efluents (SR2)

Mining Chemical Industruies

Metal tailings (PMS) (SR3)

ADVANCED WASTE PROCESSING AND RECOVERING STAGES

SR Characterization (WP1)

- Chromatographic techniques
- Spectrophotometric
- Electrochemical techniques
- Chemometrics

Advanced SR processing (WP 2)

- Green leaching
- Enzymatic processes
- Mineral Liberation
-Flotation
-Membrane pre-treatments

Separation Processes (WP3)

-Extraction Chromatography
- Ion-Exchange
- Electro membranes (ED, EDBP)
- Membrane Contactors: G/L, L/L

Chemicals Production and Recovery

- Lyophilization
- Reactive Crystallisation
-Selective Evaporation
- Selective Precipitation

RAW MATERIALS & BY-PRODUCTS

Bioactive compounds

Polyphenol extracts
Organic acids
Aminoacids
Sugars

Valuable By-products

$Mg(OH)2(s)$

$CoSO_4(s)/CoCO_3(s)/CoO(s)$

$NiSO_4(s)/NiCO_3(s)/NiO()$
NaOH
NH3, $NH4HCO3(s)$

Digital Tools for Waste Processing: Leaching, separation and purification (WP4)

Resources cycling platform and Industrial waste platform Technology (WP5,WP6)

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Inspiration for your secondment to Innovate3X (I3X): for Resilience, Restoration and Regeneration

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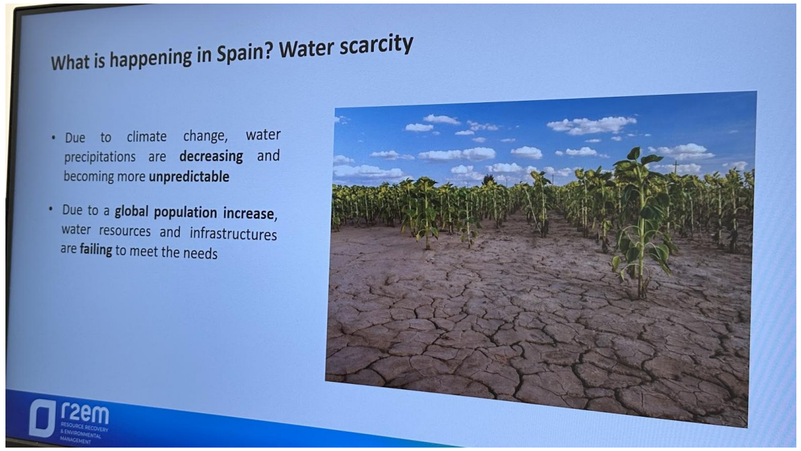
Snippets of Insights from meeting R2EM research group at UPC BarcelonaTech in July 2025

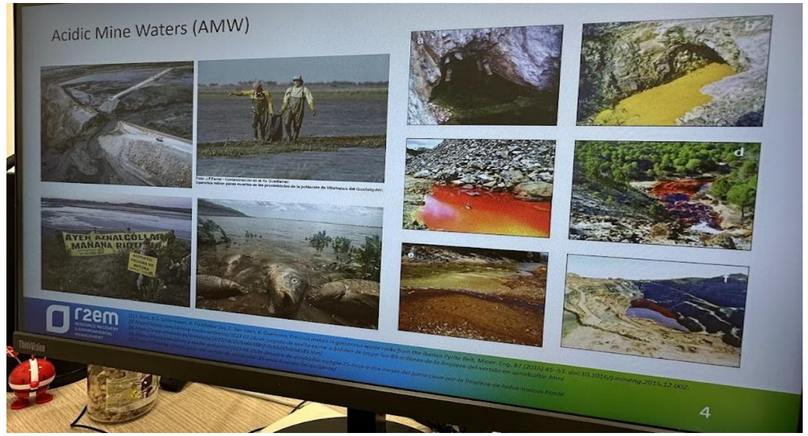
Dr. Kateryna Kryzhanivska
Researcher at LUT University,
Business School, Finland

Tackling real-world problems with I3X

What was insightful?

- Recovery of essential raw materials for industry **transition to green and low-carbon economy**
- **Metal recovery from acid streams**
- **Processes** that can be applied in metalurgy, ceramics, electronics, chemical, optical, medical, agriculture and nuclear **technologies**
- **R&I infrastructure** to **develop, pilot and scale I3X** in agriculture, energy, mobility sectors





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I3X at UPC BarcelonaTech – About the initiator

Name of Organization: UPC BarcelonaTech
Research Group/Department: R2EM group
Country: Spain

1. Background info

The **Barcelona Research Center in Multiscale Science and Engineering (CCEM Barcelona)** is a multidisciplinary hub at the forefront of materials science, in the fields of micro and nanoengineering, nanotechnology and biomaterials.

2. Research Group/Company Department

Short description: R2EM group is developing research activity on development of sustainable urban and industrial waste management cycles based on resource recovery approaches promoting circular solutions of waste to product and waste to energy. Research also involves efforts on developing environmental remediation solutions for soils and ground water remediation, process and environmental monitoring and environmental risk assessment on ports.
Link to the website: https://futur.upc.edu/idioma/en
Contact info: **Prof. Jose Luis Cortina** jose.luis.cortina@upc.edu

3. Expertise and available technologies within SMAR3TS project

1. Development of **separation processes**, knowledge of **membrane technologies**, technology **integration**, **circular processing**, digital tools for process design & optimization.
2. Membrane, sorption, and ion exchange technologies for tests in **design**, **integration**, and **simulations** of **industrial processes**.
3. Processes to **recover value-added materials** from organic waste (e.g., reusing fiber for functional foods).
4. Currently, **technologies** in waste procurement, leaking, and recovery of concentrates are at laboratory scale and need **upscaling**.
5. TRL status: 3-5. Knowledge, skills, capabilities, and further advancements are needed to **reach TRL levels 6-7**.

4. Examples of strategically relevant Innovate3X (I3X) Initiatives

Provide a preliminary description of work that needs to be done, which will be further refined and shaped throughout the secondments.
Examples:

- **Extracting high-value bioactive molecules from agri-food waste** for pharmaceutical, cosmetics and food industry applications.
- **Development of symbiotic approaches** in the chloralkaline industry, combining seawater desalination, carbon capture and utilization, and on-site chemical production; **Status:** technologies developed in the lab, but require further **industrial and market validation**; **business model development** for **industrial demo cases** of sustainable production and recovery of (critical) battery metals are needed
- **Producing critical metals for electric vehicle batteries** using urban and mining secondary resources. **Status:** development of advanced separation processes needed.
- **Regeneration processes** in the **pyrometallurgical industry**. **Status:** Industrial and market validation needed
- **Development of multi-scale approaches** for testing, separation, removal and recovery of valuable components, water and energy by developing hybrid processes.
  Status: **recovery of Sb and Bi elements in the lab**; ongoing collaboration with Atlantic Copper and Łukasiewicz Research Network - Institute of Non-Ferrous Metals (Ł-IMN) in Poland.

I3X at UPC BarcelonaTech – Alignment to R3 and to WPs

SMAR3TS domains:

1) Specify here: *one or several* ***SMAR3TS domains*** *that are* ***relevant to the work of your organization/research and innovation team****.*

<u>Nutrition</u> domain: e.g., upcycling process of agri-food waste, sustainable food packaging

<u>Mobility</u> domain: sustainable mobility and digitalization, processes for critical material recovery and reuse in the mobility sector

<u>Energy</u> domain: energy recovery, energy transition, reducing energy consumption

2) Specify here: ***<u>alignment</u>*** *of the work of your organization/research and innovation team with one or several <u>SMAR3TS focus areas</u> on <u>Resilience</u>, <u>Restoration</u>, and <u>Regeneration</u>. Share examples.*

- Regenerative food production and recycling
- Regeneration processes in the pyrometallurgical industry
- Restoration: recovery and reuse critical raw materials for the future of mobility
- Restoration: maximizing water reuse and water recovery through smart, circular and integrated solutions for sustainable energy use and production

I3X at UPC BarcelonaTech: From Lab to Market - Upcycling agri-food waste through upscaling industrial applicability and business case modelling

(1) I3X:

1. Description of Current Stage

Specify here: *What is your research group/department currently working on? Which initiatives/projects are underway under I3X? How does this work contribute to resilience, restoration, and regeneration?*

- working with agri-food waste
- refining, separation and purification technologies in the labs

Goal: to advance with the development of technologies towards technological and societal readiness and scalability, this I3X needs to focus on the development of industrial pilots.

2. Necessary skills and capabilities, across disciplines:

Specify here: *What gaps or barriers need to be addressed to move forward? Which new skills, knowledge, expertise, interdisciplinary approaches or collaborations are required?*

- Development of industrial pilots with cosmetic, pharma and food industries
- Advanced knowledge of separation and purification processes for critical raw material extraction
- Business case modelling scenarios
- Further development of technologies (e.g., in smart film food packaging)

3. Examples of challenges that need to be addressed

Specify here: *Please outline which challenges remain unresolved. You may answer in bullet points.*

1) Testing and applicability of technologies in the industry (e.g., testing the upcycling process of agri-food waste for fuel production, chemicals and materials, feed and food ingredients);

2) Business case modelling and scalability assessment scenarios of upcycling agri-food waste (e.g., on the Spanish market in olive oil; winery; fruits and juices industries);

3) Regulatory assessment scenarios – EU level

4) Domain Bio-based Economy: building the value chain for antioxidants production
5) Testing the recovery processes of polyphenols from agri-food waste including olive oil and wine industries through a circular economy
6) Validation of extraction, clean-up and concentration of polyphenol extracts from olive and wine waste (in connection with LIFE CYCLOPS project)
7) Market and Life Cycle Assessment (LCA)
8) Test of bioactive polyphenols in the industry
9) Collaboration in wastewater valorization and material recovery
10) Soil quality and waste recycling processes
11) Digital technologies for food waste reduction and improvement of food logistics
12) Development of food systems
13) Open Innovation and business model innovation – role of technologies (e.g., AI) in agrifood systems

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I3X at UPC BarcelonaTech: Processes for market assessment – LCA and regulatory assessment

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(2) I3X:

1. Description of Current Stage

Specify here: *What is your research group/department currently working on? Which initiatives/projects are underway under I3X? How does this work contribute to resilience, restoration, and regeneration?*

- **Technologies** are currently on TRL 3-4 levels and **can be further developed to TRL 5-6**
- Interest in further **validation** of bioactive polyphenols for smart filmed food packaging, purification processes, **life-cycle assessment (LCA), techno-economic assessment (TEA),** as well as seawater desalination, carbon capture and utilization, and on-site chemical production.

2. Necessary skills and capabilities, across disciplines:

Specify here: *What gaps or barriers need to be addressed to move forward? Which new skills, knowledge, expertise, interdisciplinary approaches or collaborations are required?*

• Business model evaluation analysis
• Research on food supplementary materials, animal feed application, sustainable food packaging, food materials

3. Examples of challenges that need to be addressed

Specify here: *Please outline which challenges remain unresolved. You may answer in bullet points.*

1) Recovery of polyphenols, fivers, sugars' valorization
2) Assessment of biomedical applications in pharma industry
3) Development of digital tools (e.g., digital passport for electric vehicles' (EV) batteries in the EU) – how can it be applied for the waste that is vaporized?
4) Regulatory assessment for waste material treatment
5) Water treatment
6) Business case analysis and scalability assessment; techno-economic analysis

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I3X at UPC BarcelonaTech: Assessment of scalability processes for industrial decarbonization

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(3) I3X:

1. Description of Current Stage

Specify here: *What is your research group/department currently working on? Which initiatives/projects are underway under I3X? How does this work contribute to resilience, restoration, and regeneration?*

- The research group is working on Industrial Feasibility of brine mining for Cl2(g) and Mg (OH)2(s) production in collaboration with Spanish chemical producers.
- Need to **assess the scalability** of industrial decarbonization processes.
- Also, **pure separation** of metals from mine tailings and industrial waste from metallurgical industries and urban e-waste remains a **big problem**, as the recovery process contains often a mixture of raw materials.

2. Necessary skills and capabilities, across disciplines:

Specify here: *What gaps or barriers need to be addressed to move forward? Which new skills, knowledge, expertise, interdisciplinary approaches or collaborations are required?*

- Economic feasibility assessment, TEA and LCA for industrial decarbonization
- Development of green tax/eco tax scenarios
- Understanding of industrial maturity of technologies
- Knowledge on recovery of critical raw materials
- Knowledge of hydrogen production processes
- Skills on analysis of the circular approaches to recovery of critical raw materials
- Knowledge about ion exchange
- Techno-economic analysis in industrial scale (currently only lab scale assessments are available)
- Collaboration with the government and companies needed
- Knowledge of the impact of battery waste (need for further impact assessment)

3. Examples of challenges that need to be addressed

Specify here: *Please outline which challenges remain unresolved. You may answer in bullet points.*

- Major challenge: **high costs and high energy consumption for industry** in membrane distillation and nanofiltration.
- **Development of green tax/eco tax scenarios**
- **Assess market and conditions for industrial pilots** (currently an ongoing collaboration on a first pilot with an automotive batteries manufacturing company within EU R&I Actions - METALLICO)
- **Techno-economic analysis** in industrial scale (currently only lab-scale assessments are available)
- Substitution of vacuum salt by high-quality NaCl brine in **desalination processes** (from seawater to clean water)
- **Development of decarbonization processes** to avoid evaporation/crystallization of critical raw materials
- **Business case** for a chemical company e.g., on e-waste battery recovery processes
- **Reduction of acidic mining or acidic mines' treatment processes**
- **Recovery of materials as fertilizes for soils** (developing further collaboration with the University of Palermo in Italy)
- Economic evaluation of critical and strategic raw materials recovery
- Developing scenarios for upscaling of industrial decarbonization processes (e.g., with Veolia company (France), mining companies in Australia (e.g., BHP), energy companies (with expertise on heating and cooling in Finland); and water purification processes (e.g., with industry partners in USA – e.g., RIOTINTO)
- Reducing energy consumption in nanofiltration processes
- Lithium recovery from battery waste (currently, **only experiments were done on the lab scale**, but **not tested with the industry**.
- Potential collaboration with companies such as industrial projects with RIOTINTO in Serbia, Lithium-Iberia in Spain, and Savannah in Portugal)

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I3X at UPC BarcelonaTech: Scaling industrial processes of critical raw materials recovery and application

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(4) I3X:

1. Description of Current Stage

Specify here: *What is your research group/department currently working on? Which initiatives/projects are underway under I3X? How does this work contribute to resilience, restoration, and regeneration?*

- Recovery of materials such as brine to be reused in industry, e.g., rare earth elements (REE) recovery, and managing industrial waste.
- Example of successful **nano-filtration pilot** (removing materials and allowing pure filtration tests – technology that has been commercialized – high pressure NF for separation of NaCl and CaCl2).

2. Necessary skills and capabilities, across disciplines:

Specify here: *What gaps or barriers need to be addressed to move forward? Which new skills, knowledge, expertise, interdisciplinary approaches or collaborations are required?*

- Knowledge of industrial critical raw material recovery processes
- Ability to perform economic analysis
- Experience of developing techno-economic evaluation scenarios
- Engagement of mining technology companies and research centers (e.g., RMIT and mineral processing companies in Australia, e.g., BHP)

3. Examples of challenges that need to be addressed

Specify here: *Please outline which challenges remain unresolved. You may answer in bullet points.*

- **Managing metal waste** (e.g., in the pyrometallurgical industry)
- **Interaction of hazardous metal waste with the soil**

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I3X at UPC BarcelonaTech: Development of multi-scale approaches for testing, separation, removal, and recovery of valuable components, water, and energy through hybrid processes

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(5) I3X:

1. Description of Current Stage

Specify here: *What is your research group/department currently working on? Which initiatives/projects are underway under I3X? How does this work contribute to resilience, restoration, and regeneration?*

- Engagement in R3Volution project (HORIZON-RIA - HORIZON Research and Innovation Actions) using revolutionary approaches for maximizing water reuse and water recovery through smart, circular and integrated solutions (e.g., integration of MF, UF, NF, RO, EDBP-MD).

2. Necessary skills and capabilities, across disciplines:

Specify here: *What gaps or barriers need to be addressed to move forward? Which new skills, knowledge, expertise, interdisciplinary approaches or collaborations are required?*

- **Development of technologies** related to process optimization for water reuse, energy recovery in industry, bio-based economy, circularity and sustainability assessment.
- **Commercial analysis** of technologies for separation, removal and recovery material.

3. Examples of challenges that need to be addressed

Specify here: *Please outline which challenges remain unresolved. You may answer in bullet points.*

1) Development of digital tools for modelling and control optimization of testing processes, integration of AI into testing, separation, removal and recovery of valuable components, water and energy.
2) Piloting separation, removal and recovery processes in industrial sites.

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Welcome to Innovate3X Secondments

at UPC BarcelonaTech

Research Center in Multiscale Science and Engineering, Spain

Contact:

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jose.luis.cortina@upc.edu

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EXCELENCIA MARÍA DE MAEZTU

Research at Barcelona Research Center of Multiscale Science and Engineering

UPC Hydrogen Lab

Funded by the European Union

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