ICCRAM: Roles and Capabilities

This document is organized into two distinct sections: the first section provides a detailed description of the capacities and services that ICCRAM can offer within the framework of research and innovation projects, covering its infrastructure, specialized methodologies and techniques, as well as its experience in different areas of work; and the second section presents a specific analysis of the identified calls of interest, detailing in each case the potential contributions that ICCRAM could offer to consortia, based on the requirements and objectives of each call.

List of abbreviations: CBA; Cost-Benefit Analysis, CEC; Cation Exchange Capacity, CT; Computed Tomography, EUSO; European Union Soil Observatory, LCA; Life Cycle Assessment, LCC; Life Cycle Costing, LUCAS; Land Use/Cover Area frame statistical Survey, MCDA; Multi-Criteria Decision Analysis, PAH; Polycyclic Aromatic Hydrocarbons, PFAS; Perfluoroalkyl and Polyfluoroalkyl Substances, PGPR; Plant Growth-Promoting Rhizobacteria, PLFAs; Phospholipid Fatty Acids, QSAR; Quantitative Structure-Activity Relationship, SIP; Stable-Isotope Probing, SMEs; Small and Medium-sized Enterprises, SSH; Social Sciences and Humanities, SSbD; Safe and Sustainable by Design, TEA; Techno-Economic Analysis, TPH; Total Petroleum Hydrocarbons, TRL; Technology Readiness Level, UCC+i; Unidad de Cultura Científica e Innovación (Scientific Culture and Innovation Unit).

Main Capacities: Environment and Soil Health

- **Soil characterization:** Standardized protocols to determine soil physical-chemical properties: texture, bulk density, water retention capacity, particle density, pH, electrical conductivity, organic matter (OM), content by Loss of Ignition (LoI), oxidizable OM, total N by dry combustion, available nutrients (ammonia, nitrate, ortho-phosphate), exchangeable cations (Ca, Mg, K, Na) and cationic exchange capacity (CEC), and available trace metals (Al, Fe, Mn, Cu, Zn). Biochemical soil analysis in rhizosphere and non-rhizosphere soil samples: microbial biomass by fumigation-extraction, basal soil respirometry, enzymatic profiling, phospholipid derived fatty acids (PLFAs) and physiological profile using BIOLOG Ecoplates. Microbiome evaluation. Soil mapping and remote sensing. Soil health monitoring. High resolution soil mapping (VERIS Q2800 (electrical resistivity) and TSM instruments).

- **Development and application of sustainable agricultural strategies:** Definition of sustainable strategies for crop production under stress conditions (salinity and drought): **Access to different agricultural areas** for field testing in olive, vineyard, cereal, other cropts. Application of sustainable practices such as biofertilizers, biopesticides, floral margins, mulching, amendments. Collaboration with farmers and agricultural associations. Experience in field testing (POLLOLE-GI, NOVATERRA, TRIBIOME), soil and crop monitoring and evaluation. Digitalization in agriculture (AI, robots, multispectral camara, phenotype evaluation). **Innovation Radar:** Improvement of soil quality strategies by the incorporation of green cover crops in Mediterranean vineyards and olive groves; Increase of biodiversity to contribute to major sustainable agronomic practices in Mediterranean vineyards and olive groves.

- **Remote sensing monitoring and Digital tools:** Drones with multispectral camara. Multispectral 3D scanner for plant phenotyping, AI and robots.

- **Computerized Tomography** (CT) for non-destructive analysis and parametrization of materials, with applications in the evaluation of internal structure, porosity, density, and defects in advanced materials. Particularly applied to soils, it allows detailed physical characterization, including analysis of soil structure, compaction, porosity, root growth pathways, and spatial distribution of particles.

- **Bioremediation, application of microbial consortia** and bio-based solutions for pollutants degradation in different matrixes. Microbial isolation and characterization, microcosm and mesocosm experiments. Innovative methods for isolation, aggregation, encapsulation and carriers. Microbiome analysis, evaluation of functional genes. Combination of bioremediation and phytoremediation for organic pollutants degradation (microbial-assisted phytoremediation).

- **Application of Nature-Based Solutions for soil and water matrix restoration:** Phytoremediation and phytomanagement strategies with different crops and non-feed-food domestic plants. Characterization, optimization and application of bacteria and fungi as Plant Growth Promoting organism. Biomass valorization. Targeting metals and organic pollutants. Physiological, molecular and biochemical characterization of the plant response to stress caused by pollutants (e.g., qRT-PCR, RNA-seq, protein studies, enzymatic activities, microscopy, etc.). Ah-doc design of wetland pilot for metal removal. **Innovation Radar:** Hybrid remediation of water combining phytoremediation and bioelectrochemical systems..

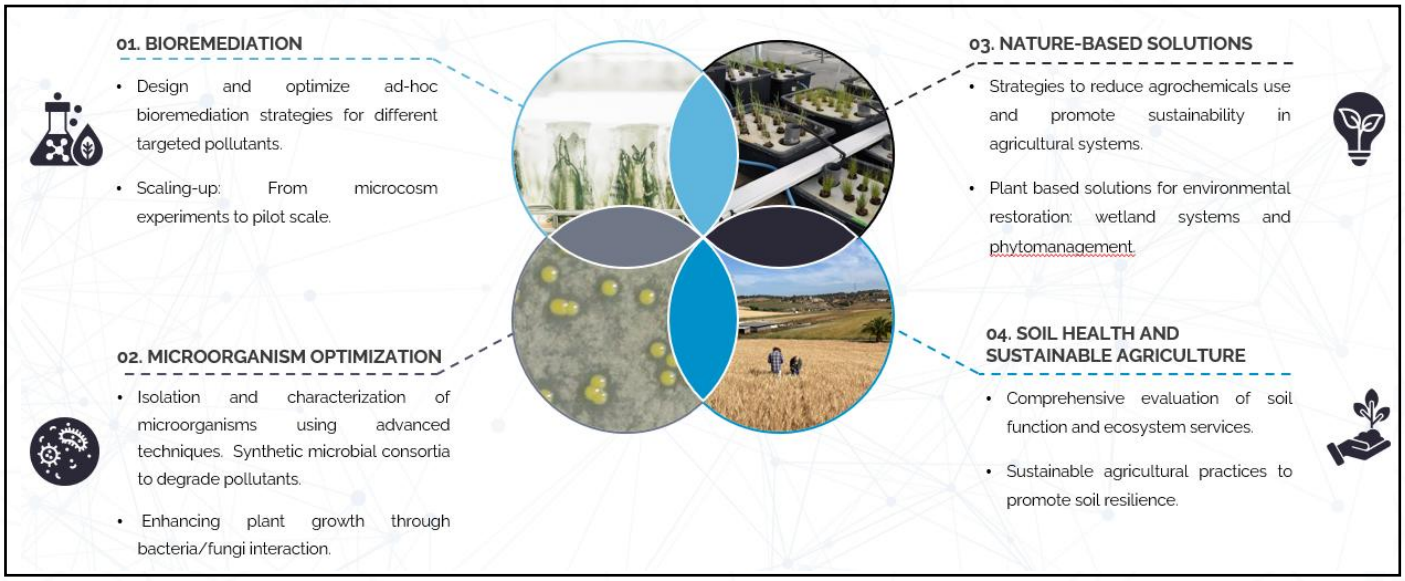
- **Isolation and immobilization of enzymes** in different matrix for different agri-foods and environmental applications (enzyme-assisted bioremediation).

- **Access to degraded areas** containing inorganic (metals), organic pollutants (pesticides, PAH and TPHs) and saline areas. Access to brownfield areas in Spain. Collaboration with different companies and clients.

- **Stable-Isotope Probing (SIP)** for advances on trace and fate of different compounds (microplastics, pollutants) in soils, crops and others.

- **Risk assessment of polluted soil and water following different in-vitro assays (toxicology capabilities). Phytotoxicity** (germination, Oxidative stress: photosynthetic pigment determination, soluble proteins, catalase and ascorbate peroxidase activities in leaf) in crops or model plants as *Arabiodpsis* or *Brassica*. Assays in phytotron with controlled conditions.

- **Sustainability assessment** of remediation technologies, nature-based solutions for restoration and agricultural strategies (Sustainability capabilities)

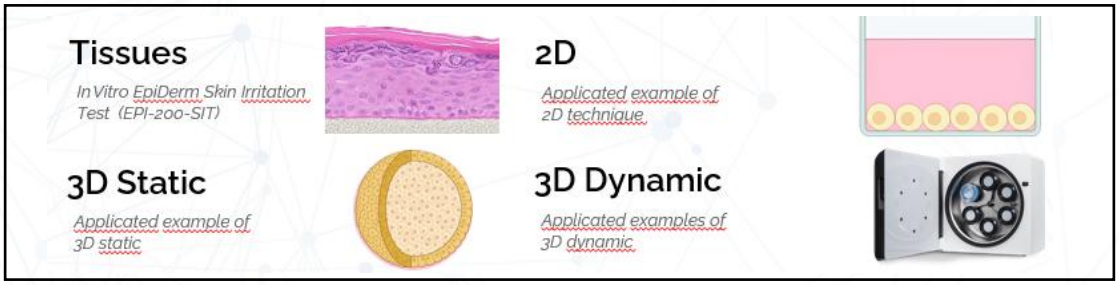


Main Capacities: Toxicology

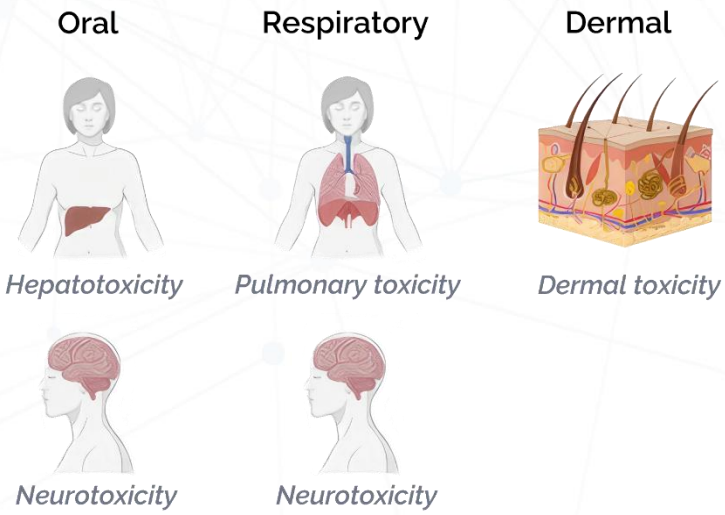
Human hazard assessment: Tests using different *in vitro* models for human toxicity:

- Models: skin tissue, hepatocyte (HepG2), neuroblast (SH-SY5Y), lung (A549) and intestine (Caco-2) cells.
- Techniques: In vitro 2D, 3D static and 3D dynamic models (ClinoStar incubator) to test cell viability, and tissues.

- Endpoints: Cellular damage & toxicity mechanisms analysis: viability assays, cell cycle, oxidative stress/DNA damage, metabolic activity, membrane integrity, localization studies, -omics technologies to determine global cellular response. Skin irritation test OECD 439 for chemicals & ISO standards 10993-1:2009, 10993-5:2009, 10993-10:2010, and 10993-12:2012 test for Medical Device Extracts (biocompatibility tests).



Models/exposure routes



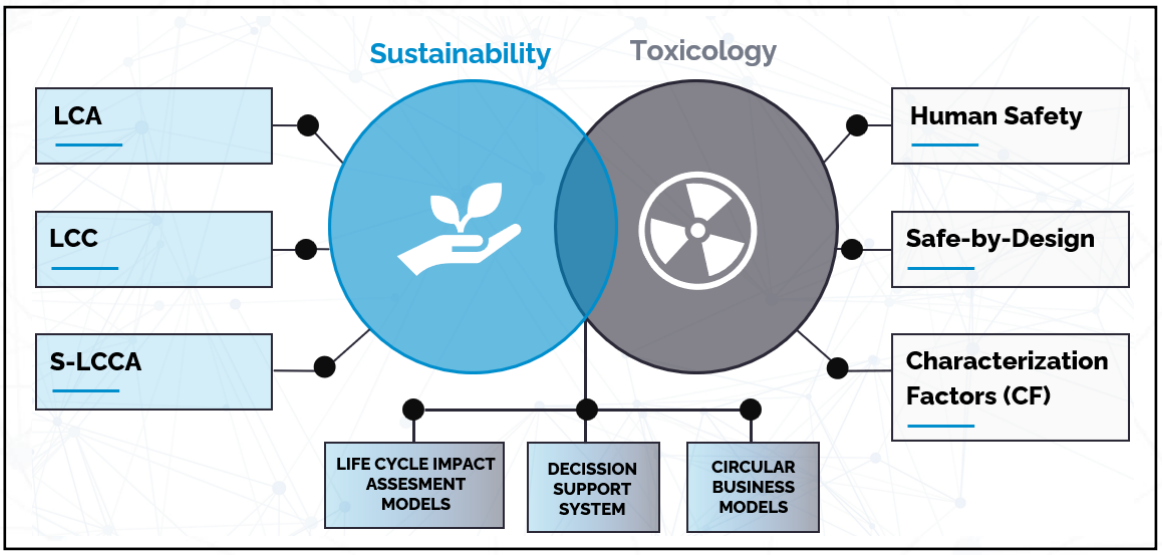
- **Environmental hazard assessment:** Tests using different in-vitro models for ecotoxicity:
    - RTgill-W1 rainbow trout cell line: Acute toxicity test OECD 249.
    - *Pseudomonas putida*
    - *Saccharomyces cerevisiae,*
    - *OECD 217 Soil Microorganisms: Carbon Transformation Test*
    - *OECD 220 Enchytraeid Reproduction Test*

- Determination of antimicrobial activities of new compounds and nanoparticles: Viability, Minimal Inhibitory Concentration, Growth curve assays, Surface attachment, Biofilm formation/disassembly assays, *In vitro* infection assays (Incubation of clinically relevant strains with human cell lines).

- **Application of the SSbD EU framework (Step 1 - Step 5)**
    - Definition of criteria for SSbD and selection of endpoints.
    - Ensure the compliance with the SSbD framework identifying needs of refinement of the processes/formulations.
    - Review the available data on the hazard potential of currently used chemicals/materials and SSbD's alternatives identifying data gaps.
    - Identify relevant exposure and risks hotspots using in silico tools to predict the risks and exposures of chemical substances for both humans and the environment
    - Evaluate human and environmental safety of the SSbD's alternatives and perform a comparative hazard assessment with the SoA chemicals and materials.

  Development and application of *in silico* models – QSAR-based toxicity. Investigate, assess and develop improved predictive realistic models for quantifying effects on human health (risks/benefits) of processing, materials, chemicals and/or food ingredients (and/or mixture of them). Application of machine learning approaches.

Main Capacities: Sustainability and circular economy



- **Standardized or widely accepted methodologies** as Life Cycle Assessment (LCA), Life Cycle Costing (LCC), social-LCA, Cost–Benefit Analysis (CBA), Techno-Economic Analysis (TEA), Social – LCA.

- Experienced in the **socioeconomic assessment** of emerging technologies with low TRL, conducting upscaling scenarios of production processes to estimate costs and social impacts at an industrial scale. On the social aspects, social assessment, including top-down approaches to gather strategic insights, often narrower but a higher-level goal (UNEP SETAC guidelines applications) and bottom-up methodologies (stakeholders' consultations, focus groups, etc.), capturing grassroots realities and specific data points, and insights on real-world conditions.

- **Studies about monetized LCA** results into financial analysis to assess project profitability by integrating externalities into the selling price and comparing it with similar materials, while consistently considering and evaluating uncertainty (experience in GREENER, PHYBI, BIOMAC).

- **Novel methodologies for sustainability assessment** (economic valuation of ecosystem services, prospective LCA, Multi-Criteria Decision Analysis (MCDA).

- Contribution to meeting the **Ecodesign for Sustainable Products Regulation** EC approach.

- Contribution to the implementation of the **Critical Raw Materials Act**: wide expertise in the evaluation of CRMs (mapping resources, analysis and report of supply chain, demand, risk of supply, substitution strategies and policy and technology recommendations). Part of the SCCREEN, the European Expert Network in CRMs.

- Expertise in the application of the **SSbD framework** and contribution to the improvement the methodology. Participation in the JRC consultations and bootcamps, presentation of case studies in the JRC workshops. Leader of its implementation in HE Projects: NEFERTITI, FREEME, SAFARI, FUELS-C, etc.

- Expertise in the design of circularity scenarios, in collaboration with national and international industries. Leader of all the SSbD activities within IRIDISCENTE national project (AI technologies for new SSbD iron-alloys from scrap)

Main Capacities: Modelling

- **In silico design of safe, sustainable and functional materials**. Multiscale materials modelling, design and properties (physicochemical) prediction: Deep Eutectic Solvents, fuels, surface and interfaces, 2D materials… Singular skills: Artificial Intelligence - driven Life Cycle Assesment:

    - AI - based methodologies and tools can be used for LCA predictive development. Two different approaches will be considered: (i) supervised learning: with the objectives of regression and classification, (2) unsupervised learning: for data analysis and clustering.

    - Main objectives that can be tackled: predicting missing (inventory) data for materials and processes, including production condition, estimating life cycle impacts, providing tools for materials and processes optimization considering sustainability, developing simple and reliable LCA tools for non-expert users / SMEs, revealing key factors to improve sustainability by in silico design of materials and processes.

    - The methodologies will be developed around groups of materials / processes considering differences in technologies, e.g.: metal nanoparticles // graphene and 2D materials // organic small molecules // bio and natural materials.

- **Biodegradation mechanisms of pollutants: evaluation of degradation mechanisms of pollutants (PFAS, PAH, Pesticides) based on their chemistry** cationic aggregation, chain length effect, per/poly, molecular/polymeric, acidic/sulfonic...) as well as on their transport in the medium (water/soil). Development of mathematical models to evaluate the effect of different factors that can influence the remediation (environmental conditions, pH status, temperature, changes, concentration of nutrients, bacterial community composition). In silico approaches to determine the potential toxicity of the pollutants over microbial community using models of cell membranes, protein docking together with the concepts of Adverse Outcome Pathways (AoP) and Molecular Initiative Event (MIE). Artificial intelligence and Machine Learning for developing predictive toxicity models of considered pollutants.

Main Capacities: Electrochemistry and Energy Storage

- **Battery prototyping, testing and recycling strategies**: Molecular engineering, chemical and electrochemical characterization of active materials for redox flow batteries; electrode and ink/slurry preparation (ball milling, shear-force homogeneizers, furnaces); flow and non-flow battery assembling (e.g. Ar-filled glovebox); battery prototyping by additive manufacturing (SLA 3-D printer) at TRL 4; electrochemical characterization of batteries (e.g. EIS, cyclers, climate chambers); advanced analytical techniques for in situ/operando characterization of materials and key processes in batteries (e.g. scanning electrochemical microscopy, UV-Vis and Raman spectroelectrochemistry, XRD); development of new battery recycling strategies (e.g. injectable battery, Li recovery); development and validation of novel concepts in electrochemical energy storage.

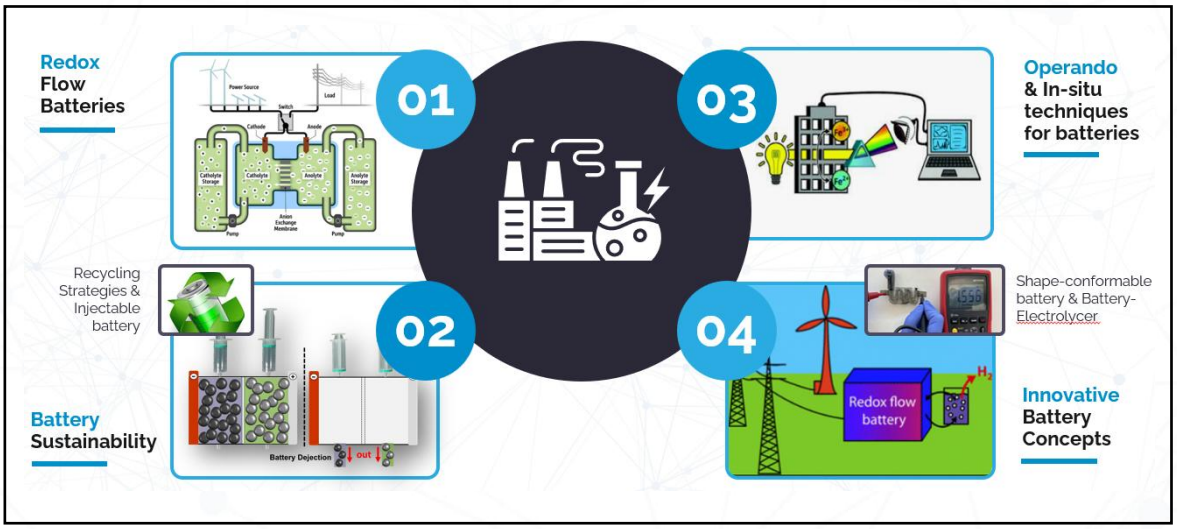
- **Preparation of electrodes:** Shear-force homogenizers for the preparation of slurries for the fabrication of self-standing solid booster hierarchical structures. Ball milling as alternative to the shear-force homogenizer for the preparation of slurries for the fabrication of self-standing solid booster hierarchical structures. Furnace up to 1.200 ºC for possible thermal treatment. SLA 3-D printer (x2) for the preparation of the molds for self-standing solid booster hierarchical structure.

- **Battery prototyping, testing and recycling strategies**: Molecular engineering, chemical and electrochemical characterization of active materials for redox flow batteries; electrode and ink/slurry preparation (ball milling, shear-force homogeneizers, furnaces); flow and non-flow battery assembling (e.g. Ar-filled glovebox); battery prototyping by additive manufacturing (SLA 3-D printer) at TRL 4; electrochemical characterization of batteries (e.g. EIS, cyclers, climate chambers); advanced analytical techniques for in situ/operando characterization of materials and key processes in batteries (e.g. scanning electrochemical microscopy, UV-Vis and Raman spectroelectrochemistry, XRD); development of new battery recycling strategies (e.g. injectable battery, Li recovery); development and validation of novel concepts in electrochemical energy storage.

- **Preparation of electrodes:** Shear-force homogenizers for the preparation of slurries for the fabrication of self-standing solid booster hierarchical structures. Ball milling as alternative to the shear-force homogenizer for the preparation of slurries for the fabrication of self-standing solid booster hierarchical structures. Furnace up to 1.200 ºC for possible thermal treatment. SLA 3-D printer (x2) for the preparation of the molds for self-standing solid booster hierarchical structures.

- **Electrochemical characterization:** Potentiostats for the electrochemical characterization in 3- electode configuration, half-cell and full cell. Electrochemical cyclers (x16) from 0.1 A to 6 A up to 5 V for long operation testing of batteries. Ar-filled glovebox for anhydrous non-aqueous electrochemistry. Climate chambers (240 L, 60ºC / -10 ºC) with controlled temperature for long operation testing of batteries.

- **Prototyping:** Peristaltic pumps (x5) the redox flow battery prototypes. SLA 3-D printer (x2) for the preparation of electrochemical reactors. Automatic blade cutting machine for the fabrication of specific prototype design (frames, gaskets, etc).



Main Capacities: Polymers design, synthesis and characterization

- **Development of advanced materials** (aromatic polyamides, PU adhesives and foams, etc.), and smart polymers ad hoc (including sensory and reactive materials) for the detection, quantification and/or removal of chemical and biological targets with application in food safety (e.g. detection of heavy metals, nitrite and biogenic amines, antimicrobial materials, lactose elimination), biomedicine (e.g. detection of Legionella pneumophila, SARS-CoV-2), civil protection (bactericide high-performance textiles for first responders, detection of nitroaromatic explosives, TATP, cyanide), environmental control (e.g. pesticides detection and removal, bisphenol A, nitrate, and textile dyes removal), etc. Full characterization of polymeric materials (NMR, FT-IR, TGA, DSC, SEM, EA, AFM, ICP-MS, EI-HRMS, etc.).

- **Materials chemical recycling.** Depolymerization for upcycling of polymeric materials through chemical recycling (multilayer film separation, organocatalysts for green depolymerization, etc). Biosensing identification and quantification of sources towards understanding the plastic pollution entry points and their characteristics. Assessment of degradation under different environmentally relevant conditions, including field testing. Understanding on (bio)degradation on different plastic materials. Modelling fate (including degradation) and transport within and between different environmental conditions, including field testing.

Main Capacities: Other capabilities

- **Processing food and feeds trams.** Physicochemical characterization, biological monitoring and human health evaluation.

ICCRAM: Materials and Equipment

Scanning Electron Microscopy (SEM) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Gas chromatography-mass spectrometry (GC-MS). Flow Cytometer Cytoflex SRT, QuantStudio Real-Time PCR System and Plant culture chamber MLR-352H-PE (PHCBI).

- A fully equipped molecular and microbiology laboratory with 4 biosecurity level II flow-hoods, 5 culture incubators, 2 centrifuges, 3 microcentrifuges, autoclave, freezer -80ºC), plate reader (BioTeck), fluorescence microscope, spectrophotometer (Denovix DS-11), electrophoresis, DNA/RNA/protein related equipment, FastPrep-24TM Classic Bead Beating Grinder and Lysis System (MP Biomedical).

- Labs specialized in soil physical, chemical and biochemical analysis. Microwave digester Millestone ETHOS ONE and microwave extractor ETHOS X, ICP-OES Spectro Genesis for trace metals and metalloids determination, segmented flow SKALAR San+ for the analysis of nutrients (nitrate, ammonium and phosphate), combustion C/N analyzer LECO TruSpec, TOC-TN in liquid samples Shimadzu VCN, Vacuum concentrator and Liophylizer Thermo, fluorometric microplate reader TECAN Gensis, Capillary Electrophoresis (CE-DAD) Agilent, and GC-FID VARIAN for PLFA profiling, etc. Greenhouse (128 m2) complemented with double 400 L climatic chambers (Ibercex) with controlled photoperiod conditions, either for assays with plants and/or soils during bioremediation experiments.

- Computed Axial Tomography (CAT). Stable Isotope Laboratory.

- Simapro for LCA.

Additional Capacities: Communication and outreach potential of the University of Burgos

- Capacity for coordination of Communication and Dissemination WP. Example: https://surfbio.eu/project/ ; https://www.bioremproject.eu/

The University of Burgos counts with the Scientific Culture and Innovation Unit (UCC+I, see below) for communicating, disseminating and organizing a wide range of activities and launching to the general public the innovation outputs arisen from this medium-sized but powerful University. UBU counts with the facilities of "La Estación", an innovative community building space for co-creation activities mainly relying on STEM (Science, Technology, Engineering and Mathematics) disciplines. This building, created between the University of Burgos and the City Council, harbors hands-on activities and a multitude of divulgation events and specialized workshops, emphasizing the educational approach. Strikingly, this is a brownfield, built upon the old railway station of the city, thus being a potential polluted site to be considered within the framework of forthcoming bioremediation or similar projects

- **The UCC+i of the University** has three main aims since November 2014: i. Research results communication and dissemination of the research groups of the university and its projects; ii. Science dissemination to the general population; iii. Promotion of STEM vocations. Since this date the UCC+i has been involved in the communication of research results from the scientist of the university by general mass media (newspapers, radio, tv news, etc.) by preparing press release. Management of social media such as: Twitter, Facebook, Instagram and YouTube channel with the brand UBUInvestiga. The office also controls the blog UBUInvestiga dedicated to the dissemination of research and science and technology news.
  During this time, the office has been involved in the development of 21 projects of Science Communication funded by the Spanish Foundation for Science and Technology, Ministry of Science and Innovation of the Spanish Government. The current team is composed by 3 journalists dedicated to the communication area, and for 5 people dedicated to the science dissemination and the promotion of STEM vocations among children and young people. The team organized the VII National Social Science Communication Congress held in Burgos in October 2019.

- **Citizen Science Expertise:** University of Burgos is very active in Citizen Science projects and initiatives, with a sustainability and environmental focus: EcoCreaLab (FCT – 18 – 13302) (Spanish Government), "Collaborative Laboratories and Citizen Science for the Study of Aquatic Ecosystems"; AquaCoLab (FCT – 19 – 15215) (Spanish Government), "Collaborative Laboratories and Citizen Science for the Surveillance of the Quality of Fresh Water Systems of the Province of Burgos", AquaCoLab (FCT – 20 – 15610 and FCT-21-16785) (Spanish Government) Collaborative Laboratories and Citizen Science for the Monitoring of Freshwater System Quality, Plastic Pirates in Spain (FCT-22-18156) (Spanish Government) and LIFE – NITRAZENS (EU project) The University of Burgos also collaborate with

- other citizen science projects, such as Plastic Pirates Go Europe and ECHO soil project (which we are ambassadors). These ongoing projects, have the target to involve the citizens, from very diverse backgrounds, from the very beginning of the scientific process to tackle, by co-creating under a bottom-up approach, to reach the commitment on the principles of the citizen science, which are a key in all EU Missions. Powerful networks of volunteers and collaborators involving all types of stakeholders already exist, meaning a huge advantage for forthcoming projects of any nature, favoring networking, and any ambitious R&I goals, placing citizens in the focus of the movements across EU and beyond. As a result of these projects and collaborations, the university is also present and required at national and international environmental and sustainability conferences, as well as in scientific publications and technical reports related to citizen science ("RED4C Guide: Citizen Science for Monitoring Climate Change in Ecosystems" and "To understand and enhance the impacts of citizen science in Spain").

- University of University of Burgos has promoted the creation of the Digital Innovation Hub on Livestock, Environment, Agriculture and Forest (DIH-LEAF), grouping agroindustry, research institutions and rural associations. Some of these members of DIH-LEAF are directly linked with the agricultural sector using innovative practices such as precision farming, efficient irrigation systems, livestock, etc., and can stablish a platform for the creation of these web-based system taking advantage of the UBU expertise on advanced machine learning.

DIH-LEAF brings together different actors connected with the production sector and from different technology initiatives. Universities, technological centers, companies, producer associations, non-profit associations, all of them (50 organizations) take part in DIH-LEAF with the objective to face the wager of digitalization and technological innovation in this broad productive sector. DIH-LEAF is established as an independent and unique digitalization ecosystem with the final objective to digitalize these entities by improving their efficiency, competitiveness and sustainability throughout the application of Information and Communication Technologies (ICTs). This way, it also contributes to the sustainable development of both rural and urban areas. The services offered by DIH-LEAF are mainly focused on Assessment and awareness about digital opportunities, Digitalization plan: Deep analysis and audit, transformation plan, experts support and follow up; Prototyping and Testing; Training; Wide network for knowledge exchange and financing opportunities.

DIH-LEAF Website: https://www.dih-leaf.eu

Participation in working groups. Members of networks

- Members of Red Española de Compostaje (Spanish Composting Network) and members of the Spanish Society of Soil Science. Organizers of the CONDEGRES.
- Member of NETSOB: International Network on Soil Biodiversity.
- Member of INSOP: International Network on Soil Pollution.
- Member of the Nanosafety Cluster.
- Member of the European Federation of Biotechnology.
- Core group member of the ALL4BIOREM cluster.
- Members of NICOLE.
- Member or the Machine Intelligence Research Labs (MIR Labs).
- Member and the Chair of the IEEE Systems, Man & Cybernetics Society Spanish Chapter.
- Ambassadors of ECHO project.
- Members of the Spanish Network on LCA.
- Members of Graphene Flagship initiative, to advance Europe´s strategic autonomy in technologies that rely on graphene and other 2D materials.