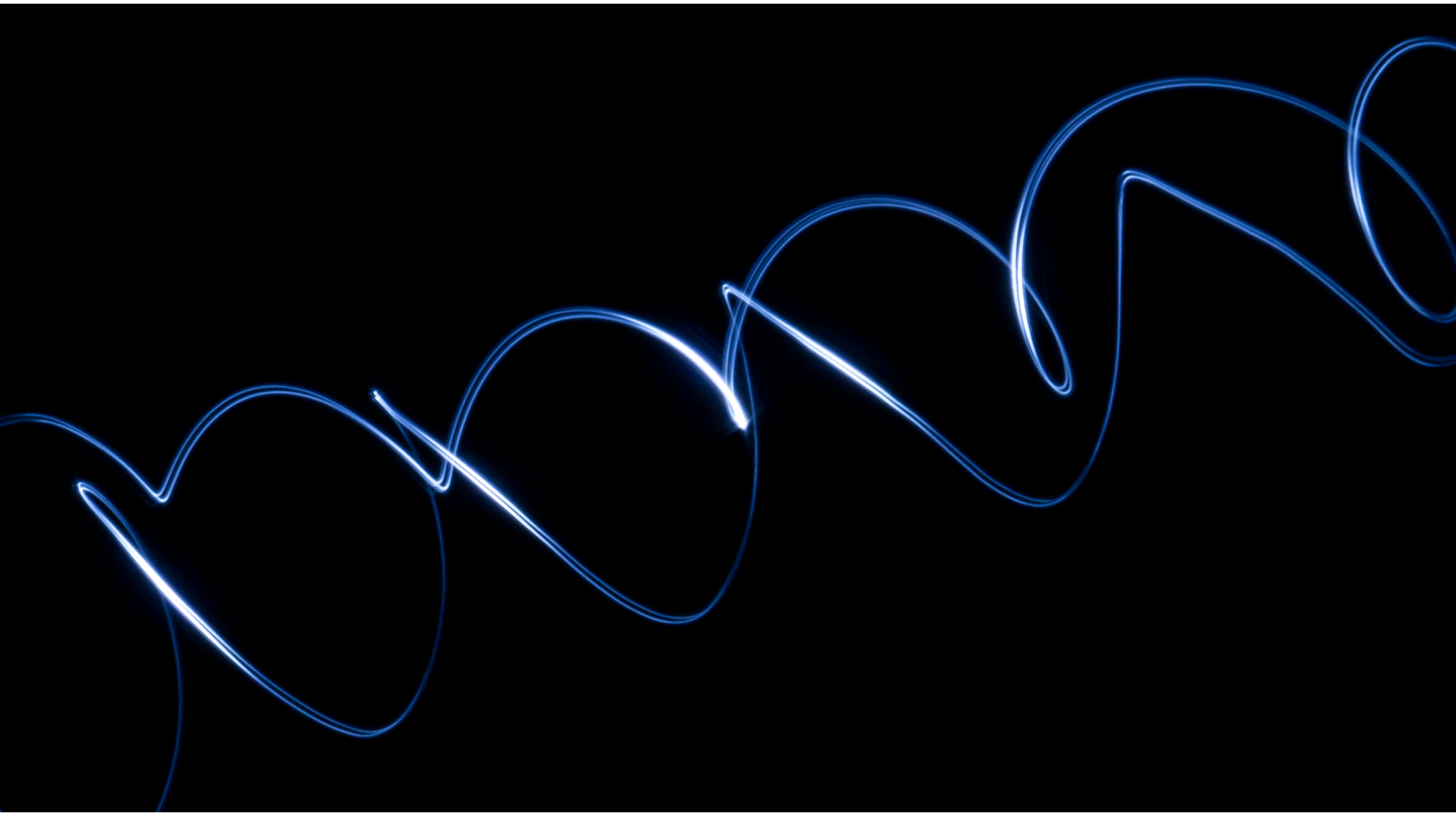
COST Action CA19123 Conference

PHOENIX: Protection, Resilience, Rehabilitation of damaged environment



BOOK OF ABSTRACTS

PHOENIX MID-TERM CONFERENCE ON BIOELECTROCHEMICAL SYSTEMS (BES)

29 FEBRUARY 2024
ROME

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EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

+PHOENIX-

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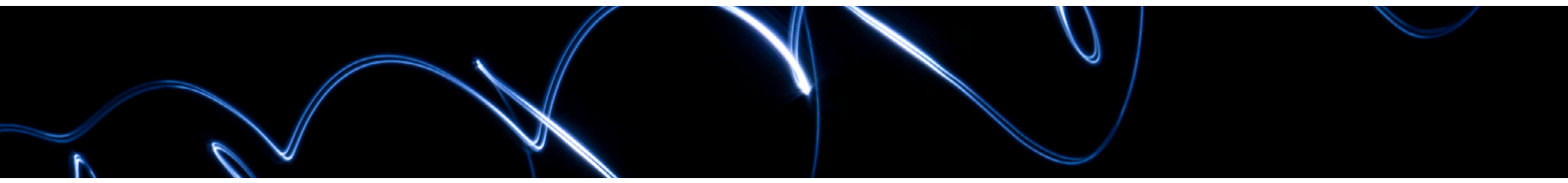

PROGRAM

MORNING SESSION: 9:00 - 13:00
Session opened to external actors / stakeholders / students.

09:00 - 09:20 **Registration and Networking**

09:20 - 09:50 **Opening Remarks**
Intervention - PHOENIX Chair and Co-Chair
Intervention - Wroclaw University of Science and Technology
Intervention - PAS Scientific Center in Rome

09:50 - 11:15 **Plenary Session**
Introduction to bioelectrochemical systems technology
Guest researcher's presentations

11:15 - 11:30 **Coffee break**

11:30 - 13:30 **Plenary Session**

European Funding Opportunities + Audience Q&A
APRE. Overview of possibilities of participation in European R&I programmes - **Horizon Europe** calls and **European Innovation Council**

13:30 - 14:30 **Lunch break**

AFTERNOON SESSION: 14:30 - 17:00
Session dedicated to PHOENIX members and guests

14:30 - 17:00 **Plenary Session**

WG presentations - progress and collaborations

17:00 - 18:00 **Conference Wrap-Up and Thank You**

18:00 onwards: **Networking Dinner**

PLANT MICROBIAL FUEL CELLS FOR BIOELECTRICITY GENERATION AND SOIL DECONTAMINATION: AN EXPERIMENTAL DESIGN WITH AROMATIC PLANT

Valeria Ancona[1], Cristina Cavone[1], Domenico Borello[3], Paola Grenni[2], Carlotta Cosentini[3], Anna Barra Caracciolo[2]

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The remediation of contaminated soils, as recommended by the Circular Economy Action Plan (CEAP) adopted by the European Commission in March 2020, requires environmentally friendly and cost-effective approaches. New bioelectrochemical systems such as plant microbial fuel cells (PMFCs) are a promising technology for soil remediation. In this system, solar energy can be converted into bioelectricity by microbial populations in the rhizosphere. To assess the capabilities of PMFCs in bioenergy production and recovering a soil contaminated by heavy metals (HMs) and polychlorinated biphenyls (PCBs) of Southern Italy, an experimental design has been customized by using an aromatic plant species (L. angustifolia Mill.). The final aim of this experiment is to achieve ecological and economic benefits through: (i) the production of bioelectricity, (ii) the soil recovery from contamination, and (iii) the supply of market-value products such as essential oils, pollutant-free.

CO_2 CONVERSION EFFICIENCY IN MICROBIAL FUEL CELLS (MFCs) AND MICROBIAL ELECTROLYSIS CELLS (MECs): ENERGY BALANCE AND PRODUCTION OF VALUE ADDED COMPOUNDS

Rosa Anna Nastro[1], Anna Salvian[2], Maria Toscanesi[3], Marco Trifuoggi[3], Chandrasekhar Kuppam[4], Vincenzo Pasquale[1], Andrea Pietrelli[5], Claudio Avignone-Rossa[2]

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We maximized the efficiency of CO_2 capture at the cathodes of our Microbial Fuel Cells (MFCs) and Microbial Electrochemical Cells (MECs) by preparing biocathodes under conditions facilitating biofilm formation and used culture media to support a gradual metabolic adaptation in *Clostridium saccharoperbutylacetonicum* NT-1 and *Ralstonia eutropha* towards the utilization of inorganic carbon. The overall effect was the constitution of an electroactive biofilm, with an activated Wood–Ljungdahl (in *C. saccharoperbutylacetonicum*) and Calvin Benson Bessam (*R. eutropha*) pathways ready to use CO_2 at the cathode of BESs, with high capture yield in MFCs and significant reduction iWn the overall start-up phase. We successfully set up Microbial Fuel Cells (MFCs) able to couple anionic (18.8 mg/L) and non-ionic (14.6 mg/l) surfactants production at the anode with formate (30 mg/L*d) in *C. saccharoperbutylacetonicum* and of POLYHYDROXYBUTYRATE (PHBs) (74±2% $V_{granules}$/Vcell) in *R. euthopha*.

ECOTOXICOLOGICAL TESTS FOR EVALUATING THE EFFECTIVENESS OF SOIL AND SEDIMENT BIORECOVERY STRATEGIES

Narciso A.[1,2], Grenni P.[1*], Mariani L.[1], Ancona V.[3], Savino I. [3], Rolando L.[1], De Carolis C.[1,4], Barra Caracciolo A. [1]

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Bioremediation strategies such as phyto-assisted bioremediation (PABR) and microbial fuel cells (MFCs) have been recently tested for improving contaminated and degraded soils and sediments. Indeed, microorganisms have a central role in pollutant degradation, removing them alone or in cooperation with plants, through their versatile metabolic capacities. PABR can be applied with several plants (e.g. sunflower and rape) depending on the specific contamination. At the same time, MFCs can also been used for improving soil quality (e.g. pesticide degradation) and gain energy from electroactive bacteria. More recently, the possibility to combine PABR and MFCs, in the so-called "Plant microbial fuel cells", has been also tested. In any case, chemical determinations are need for evaluating contaminant biodegradation and ecotoxicological analyses for excluding any toxicity of a restored matrix due to unknown chemicals.In this context, we report some examples of biotests applied for PCB and heavy metal restored matrices, using sensitive organisms such as *A. fischeri*, *H. incongruens* and *L. sativum*.

INSIGHT INTO CATALYTIC WATER SPLITTING FROM DFT MODELLING

Bartłomiej M. Szyja[1*]

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Taking three different systems as examples, different factors playng a role in the efficiency of the water splitting process will be unravelled. One of these factors is the unusual role of the heteroatoms in the Fe_2O_3-hematite surface on the efficiency. This effect, does not fit into a classical description of a co-catalyst – the Co site itself does not take part in the reaction, nor a promoter – β–CoOOH is a known water-splitting electrocatalyst. Single atom doping of the hematite surface allows this system to operate with significantly lower overpotential, comparable to β-CoOOH, but without any Co site directly involved. These results are compared with the Co_4O_4 cluster supported on the hematite surface, where a synergistic effect of the Co and Ti sites in the stabilization of particular intermediates was found. Finally, the structure of different forms of oxygen atoms in the graphene oxide is explained.

METAPROFILING OF MICROBIAL COMMUNITIES IN BENZENE-ENRICHED MFCs

Natalia Tyszkiewicz[1,3], Jaak Truu[2], Piotr Młynarz[3], Grzegorz Pasternak[1]

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Microbial fuel cell (MFC) offers unique opportunities to degrade environmental pollutants such petroleum compounds. This is possible due to the activity of electroactive microorganisms, which carry out oxidation reactions in the anodic compartment. Analysis of microbial communities is crucial to understanding the processes involved in bioelectrochemical conversion of pollutants.
The aim of the study, carried out within collaboration of COST Action PHOENIX, was to investigate microbial communities enriched in MFCs for over 160 days during benzene and glucose degradation. For this purpose, 16S rRNA and qPCR analysis were performed. Metaprofiling revealed microorganisms capable of degrading petroleum compounds, generating electricity and producing biosurfactants. *Citrobacter freundii* and *Arcobacter faecis* were the dominant species. Benzene significantly increased alpha-diversity, highlighting the complex nature of bioelectrochemical benzene degradation. This underscores the importance of extending the process of additional substrates and inoculation methods to increase microbial diversity, enhancing the power output and degradation efficiency in MFCs.

EUROPEAN COLLABORATIONS FOR IMPROVING AND UNDERSTANDING BIOELECTROCHEMICAL SYSTEMS

Grzegorz Pasternak[1], Fatma Yalcinkaya[2], Sven Kerzenmacher[3], Jaak Truu[4]

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[3]University of Bremen, Bremen, Germany
[4]University of Tartu, Tartu, Estonia

Bioelectrochemical systems (BES) development is an ongoing process due to the complexity of this technology. It requires cross-disciplinary collaboration and interactions, in order to push the BES efficiency beyond its current limits. In the course of the recent 4 years of the project, we have carried out studies on Such collaboration was possible in the course of the PHOENIX COST Action functional materials. Alongside Wroclaw University of Science and Technology, these studies comprised the modification of membranes with the Technical University of Liberec, where PVDF nanofibers modified with biosurfactants were used to prevent biofouling. In joint work with the University of Bremen, anode electrodes were investigated for their bioelectrochemical performance in heavily polluted environment containing crude oil. The biodegradation of petroleum compounds was monitored in various experiments, and in cooperation with the University of Tartu, in-depth microbial community phylogenetic and metabolic profiling was carried out. The outcomes of these works resulted in improving the long-term performance of BES, as well as understanding the nature and importance of electroactive biofilms.

THE ROLE OF REMOTE SENSING IN EFFICIENT WATER POLLUTANTS DETECTION – A REVIEW

Gordana Kaplan

This study delves into the escalating challenge of water pollution, leveraging the advanced capabilities of remote sensing technologies to monitor and analyze the quality of water bodies on a global scale. With an emphasis on the critical environmental issues of our time, such as global warming, fossil fuel dependency, and rapid urbanization, the research underscores the urgency of addressing water pollution through innovative methods. Employing a dual-phase assessment methodology, this study systematically reviews literature using "remote sensing" and "water pollution" as key search terms. The findings highlight the significance of remote sensing in identifying and quantifying water pollutants, offering a comprehensive overview of the current state of water bodies and the effectiveness of ongoing mitigation efforts. The study concludes by emphasizing the critical role of remote sensing in environmental conservation, particularly for water pollution monitoring, and outlines future research directions aimed at improving sensor technologies. This work contributes to the scientific understanding of water pollution and its management and offers practical insights for policymakers, environmentalists, and urban planners striving for a more sustainable and environmentally friendly future.

SHORT-TERM SCIENTIFIC MISSION EXPERIENCE "EXPERIMENTAL CHARACTERIZATION OF PH SPLIT PHENOMENON IN (BIO)ELECTROCHEMICAL SYSTEMS"

Marco Zeppilli, Department of Chemistry University of Rome Sapienza

The present contribution describes the STSM stages conducted by Dr Marco Zeppilli in the Laboratoire de Genie Chimique (LGC) Toulouse, hosted by Dr Benjamin Erable. The STSM topic relied on the pH split phenomenon involved in (bio)electrochemical processes which cause the acidification of the anodic chamber and the alkalization of the cathodic chamber. According to the COST 19123 Memorandum of Understanding (MoU), the STSM activity and objective were in line with different objectives and deliverables of the PHOENIX Working Group 2. During the STSM, the study of the pH split phenomenon was performed by the utilization of current controlled techniques investigating the effect of current density on pH split in anodic and cathodic chambers. The STSM activity results would be exploited in working tasks 4 and 5 of the WG2, due to the strategic importance of electrolytes pH control in various bioelectrochemical applications related to water depollution and resource recovery.

UNRAVELING THE ROLE OF CONDUCTIVE MATERIALS IN THE ACCELERATION OF METHANE PRODUCTION

Cátia S. N. Braga[1,2], A. Catarina Rocha[1], Inês Oliveira[1], Luciana Peixoto[1,3], Luciana Pereira[1,2], Andreia F. Salvador[1,2], Gilberto Martins[1,2*]

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KEYWORDS
Anaerobic digestion; conductive materials; carbon nanomaterials; pure cultures of methanogens; electrochemical analysis.

The addition of conductive nanomaterials (CM) to anaerobic digestion (AD) systems results in the acceleration of methane production (MP) and the improvement of the resilience of these systems. However, the mechanisms underlying this phenomenon are still unclear. Thus, the present work aims to evaluate the effect of adding different CM to a hydrogenotrophic and an acetoclastic culture. For this purpose, two pure cultures of methanogens were incubated in the presence and absence of 0.5 g/L of activated carbon, carbon nanotubes, carbon black, graphite, and graphene, under strictly anaerobic conditions, and MP was monitored over time. Cyclical voltammetry (CV) analyses were also performed to evaluate a possible electron transfer between microorganisms and CM. The presence of CM significantly reduced lag phases (up to 90%), increased MP rates, and reduced the incubation time by 50%. CV analysis showed no electron transfer activity between pure cultures and carbon electrodes. However, a potential electron transfer was observed for a microbial enrichment culture. Additional studies are needed to understand the mechanisms that determine MP improvement and to optimize AD systems through the addition of CM.

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This study was supported by the Portuguese Foundation for Science and Technology under the scope of the CM4Methane project (Ref: PTDC/BTA-BTA/2249/2021; DOI:10.54499/PTDC/BTA-BTA/2249/2021).

THE ENVIRONMENTAL CITIZENSHIP COMPARATIVE STUDY ACROSS SEVEN COUNTRIES IN EUROPE AND THE MIDDLE EAST

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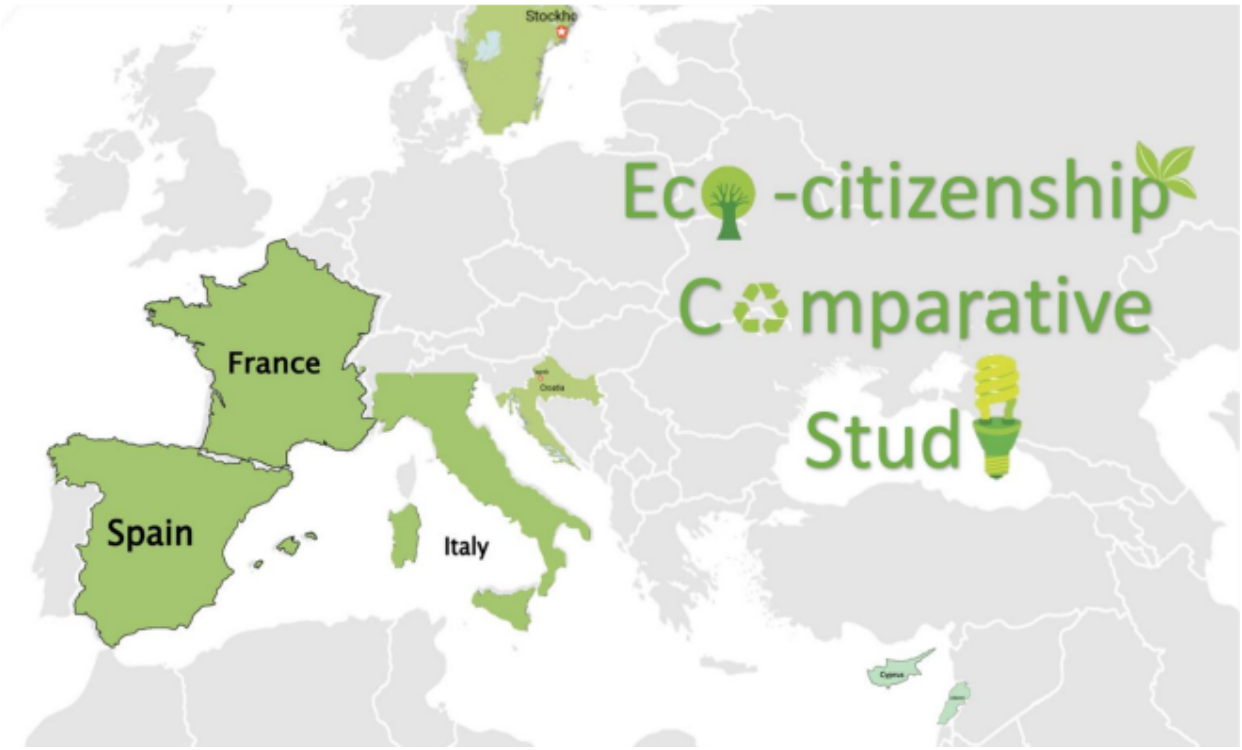
In the framework of PHOENIX aims, concerned by global warming and overuse of fossil fuel energy in a rapidly growing urbanization, investigating Eco-citizenship behaviors was found relevant to combat ecological serious threats to the world, by contributing to set appropriate awareness strategies. In this perspective, this study sought to adapt and validate an Eco-citizenship survey tool based on the “Environmental Citizenship Questionnaire" (ECQ) questionnaire developed by Hadjichambis et al. (2020), indicating the current eco-citizenship behaviors across university students of seven European and near-neighbor countries: France, Italy, Sweden, Cyprus, Lebanon, Spain and Croatia. Exploratory and confirmatory factorial analyses were used to analyze the data. Results from this comparative study revealed prevailing Eco-citizenship attitudes across countries, with a highlight on Sweden data that showed less Ecological concern among higher education students.



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