出國報告（出國類別：開會）

參加第 7 屆生物吸附與生物降解/生物整治國際研討會 (7th International Symposium on Biosorption and Biodegradation / Bioremediation – BioBio 2024)

服務機關：台灣中油股份有限公司探採研究所
姓名職稱：環境保護師 蕭因秀
派赴國家/地區：捷克
出國期間：113 年 6 月 14 日至 113 年 6 月 22 日
報告日期：113 年 7 月 15 日

摘要

本次參加在布拉格舉辦的第 7 屆生物吸附與生物降解/生物整治國際研討會(BioBio 2024)，為每 7 年召開一次，關注以生物技術解決環境污染的國際研討會，本次研討會集結捷克、義大利、西班牙等歐洲各國學者，發表相關的生物整治技術，並有廠商介紹最新儀器應用發展。

在油品相關污染整治技術上，各國學者皆有提出菌叢(consortia)降解策略，並且應用宏基因體學等分子生物技術解析微生物的組成，並且結合資料庫代謝路徑做功能上的描述；另外，植生復育與真菌整治的議題也有研究發表，顯示生物整治技術極具發展性。

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目的

隨著環境保護以及資源永續利用觀念的深入，對土壤與地下水的整治技術，不只在於降低污染危害特性，還有進一步將土地恢復原有用途的期待，因此符合此技術要求的生物整治在應用有增加的趨勢。本出國計畫與探採研究所 113 年研究題目「綠色整治技術於油品污染場址之應用(II)」研究生物處理技術相關，旨在提升污染環境中微生物的活性，使污染物的移除或分解得以加速進行。歐洲為氣候友善型產業和乾淨技術的先行者，隨著 2019 年《歐洲綠色政綱》（European Green Deal）的發布，對生物多樣性、零污染等認知提供了明確的行動藍圖，因此有許多倡議生物整治的研討會在此舉行。生物吸附與生物降解/生物整治國際研討會自 1995 年以來，每隔幾年(第 6 屆為 2017 年舉行)都會介紹相關領域最前沿的研究趨勢，並反映環境科學領域的新挑戰，例如循環經濟、廢物增值、綠色技術等。本次會議將作為展示歐盟生物整治叢集(EU Bioremediation Cluster)研究的平台之一，展示生物整治在創造更健康的土壤、淨化地下水和改善空氣品質方面的潛力。

前往參與此研討會對生物整治相關技術的開發及應用進行交流，應能使本年度研究計畫有所助益，並提升中油公司生物整治之能力，以及掌握前沿研究之國際現況。

過程

本次出國計畫行程自 6 月 14 日至 6 月 22 日，其中會議時間為 6 月 16 日至 6 月 20 日，共舉行 5 天。開幕式時主持人提及本次為第 7 屆的 BIOBIO 研討會，並介紹成立研討會的沿革，與每 7 年舉行的 BIOBIO 研討會對環境議題，以及生物技術發展的關注。會議的發表緊湊，大致的議程如下：

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<tr><td>塑膠和微塑膠：破碎、監測、生物降解、歸宿、回收</td></tr>
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頑固化合物的生物降解、
環境污染(土壤、沉積物、空污、海污)、
綠色(生物整治)技術、微藻生物精煉、
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生物多樣性與污染物的生物降解、
塑膠和微塑膠：破碎、監測、生物降解、歸宿、回收、
毒性與風險、
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詳細議程與各演講專題細節如研討會手冊所示：

DETAILED SCIENTIFIC PROGRAM

Sunday, June 16, 2024

15:00–16:30 Registration

16:30–16:40 **Opening ceremony:**
Kateřina Demnerová (UCT Prague)

16:40–18:00 **ENVIRONMENTAL POLLUTION**
Chairpersons: Giulio Zanaroli, Kateřina Demnerová

17:00–17:40
Plenary lecture
Giulio Zanaroli
(Università di Bologna, Italy)
Challenges in the intensification of organohalide respiration processes in marine

17:40–18:00
Klara Slezakova
(University of Porto, Portugal)
Understanding child exposure to indoor air contaminants: a case study of sports environments

18:00–19:30 **Welcome reception**

Monday, June 17, 2024

9:00–13:00 **GREEN TECHNOLOGIES (BIOREMEDIATION TECHNOLOGIES), MICROALGAE-BASED BIOREFINERIES, AND PHYTOREMEDIATION**
Chairpersons: Joan García, Dr. Bin Cao

9:00–9:40
Plenary lecture
Joan García
(Polytechnic University of Catalonia, Spain)
Cyanobacteria microbiomes for bioplastics long-term production

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9:40–10:00
Simona Di Gregorio
(University of Pisa, Italy)
The innovative soil-omic® process for the *in situ* decontamination of soils and groundwaters contaminated by total petroleum, polycyclic aromatic hydrocarbons and heavy metals. The validation on the operational scale in Zorrotsaurre, Bilbao, Spain.

10:00–10:20
Claudia Ortiz-Calderón
(University of Santiago de Chile, Chile)
Indigenous cyanobacteria as a multifunctional biotechnological tool for the mitigation of carbon emissions

10:20–10:40
Fátima Jesus
(University of Aveiro, Portugal)
Bioremediation of wastewater using bivalves: comparative assessment of the potential of biofiltration and biosorption

10:40–11:00 **Coffee break**

11:00–11:40
Plenary lecture
Bin Cao
(Nanyang Technological University, Singapore)
Biofilm Engineering for Environmental Sustainability

11:40–12:00
Jinyao He
(Helmholz Centre for Environmental Research, Germany)
DC electric fields promote biodegradation of a waterborne contaminant in biofilter systems

12:00–12:20
Diogo Alexandrino
(University of Porto, Portugal)
Ciimar blue biobank: a repository of marine biological resources with biotechnological potential

12:20–12:40
Elisa Ghitti
(University of Milan, Italy)
Root exudates modulate the interactions between plants and xenobiotic-degrading bacteria and potentially improve polychlorinated biphenyls (PCBs) rhizoremediation

12:40–13:00
Anamaria Gentile
(University of Salerno, Italy)
Monitoring antibiotic resistance in urban soils: a comprehensive study of arb presence and resistance levels in Milan, Italy

13:00–14:00 **Lunch**

14:00–15:00 **WATER POLLUTION & WASTEWATER TREATMENT**
Chairpersons: Tomáš Macek, Tomáš Cajthaml

14:00–14:20
Cosimo Masini
(DND Biotech, Italy)
Application of natural and modified zeolites for water filtration

14:20–14:40
István Fekete
(Bay Zoltán Nonprofit Ltd. for Applied Research, Hungary)
Secondary raw materials as potential adsorbents

14:40–15:00
Alice Melzi
(University of Milan, Italy)
Reduction of hexavalent chromium and detection of enzymatic activity in *Rhodococcus qingshengii* strain SC26

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15:00–16:00 **BIODEGRADATION OF RECALCITRANT COMPOUNDS**
Chairpersons: Tomáš Macek, Tomáš Cajthaml

15:00–15:40
Plenary lecture
Tomáš Cajthaml
(Director of Institut of Environmental Studies, Charles University, Czechia)
Per- and polyfluoroalkyl substances - eternal chemicals; is there a forever solution

15:40–16:00
Adam Sochacki
(Czech University of Life Sciences Prague, Czechia)
Reversible transformation of sulfamethoxazole by biogenic manganese oxides and manganese oxidizing bacteria

16:00–16:40 **Coffee break**

16:40–17:30 **SHORT ORAL LECTURES**
Chairpersons: Hana Stiborová, Simona Lencová

Andrea Franzetti
(University of Milano Bicocca, Italy)
Commercial products for the bioremediation of hydrocarbon-contaminated soil: characteristics and effectiveness

Jofre Herrero
(Eurecat, Technological Centre of Catalonia, Spain)
Guidelines for Mycoremediation - Replicability to Boost Implementation

Alice Melzi
(University of Milan, Italy)
Microporous microcarrier biofilm for copper removal from industrial wastewaters

Abdul Rehman
(University of the Punjab, Pakistan)
Utilization and removal of azo dyes, and plastic by metal-resistant *Ochrobactrum intermedium* isolated from industrial wastewater

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Christoph Bloss
(Helmholtz Institute Freiberg for Resource Technology, Germany)
Comparative analysis of next-generation sequencing data in phage display trials:
a bioinformatics approach for recycling fluorescent powder from fluorescent light bulbs

Marco Andreolli
(University of Verona, Italy)
Isolation, characterization of biosurfactant producing bacteria and their application to enhance pesticides degradation in agri biobed system

Anna Poli
(University of Torino, Italy)
Microbial diversity as a possible solution for restoring a PAHs contaminated soil

17:30–18:30 **PLASTICS & MICROPLASTICS: FRAGMENTATION, MONITORING, BIODEGRADATION, FATE, RECYCLING**
Chairpersons: Hana Stiborová, Simona Lencová

17:30–17:50
Sonja Harter
(Helmholtz Institute Freiberg for Resource Technology, Germany)
Engineering of polymer-specific and high-affinity binding peptides as a platform for microplastic valorization

17:50–18:10
Rafaela Perdigao
(University of Porto, Portugal)
Screening marine bacteria for plastic degradation: insights from net biofilms and hydrocarbon-degraders

18:10–18:30
Marcus A. Horn
(Leibniz University Hannover, Germany)
Effect of earthworms and fungi on the mineralisation of biodegradable and non-biodegradable plastics: importance of isotope tracing techniques

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18:30–19:30 **POSTER SESSION WITH A GLASS OF WINE**

BIODEGRADATION OF RECALCITRANT COMPOUNDS

P1
Tatiana Stella
(M3R-Monitoring and Management of Microbial Resources Srl, Milano, Italy)
Biopile technology: Upscaling of total petroleum hydrocarbons (THP) contaminated soil treatment at industrial scale

P2
Jesus Berganza
(GAIKER Technology Centre, Basque Research and Technology Alliance, Zamudio, Spain)
Assessment of the bioremediation potential of soil contaminated with hydrocarbons from a fuel spill_Berganza

P3
Tiago Maia
(CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Portugal)
Investigation of the interplay between bacterial deflurination and fluoride toxicity

P4
Jose Carlos Castilla-Alcantara
(ICCRAM, University of Burgos, Burgos, Spain)
Soil bioaugmentation based on colloid biology to improve degradation of recalcitrant pollutants

P5
Camilla Valli
(Department of Food, Environmental and Nutritional Sciences, University of Milan, Italy)
Dihydrogen (H_2) pulses for possible application in groundwater bioremediation from chloroethenes

ENVIRONMENTAL POLLUTION (SOIL, SEDIMENT, AIR POLLUTION, MARINE POLLUTION)

P6
Elisabetta Loffredo
(Department of Soil, Plant and Food Sciences, University of Bari, Italy)
Untreated plant waste of the mediterranean region as biosorbents of persistent organic pollutants

P7
Verónica Peña-Álvarez
(University of Oviedo, Mieres, Spain)
Enhancing arsenic phytoextraction rates: A nano-phyto-bioremediation approach

P8
Lila Aldakheel
(King Abdullah University of Science and Technology, Thuwal, Saudi Arabia)
Exploring plastic-degrading microbial communities in Red Sea-associated mangrove soils

P9
Elisabetta Loffredo
(Department of Soil, Plant and Food Sciences, University of Bari, Italy)
Byproducts of bioenergy production as sustainable tools to mitigate soil pollution

P10
Hana Horváthová
(The Centre of Environmental Services, Bratislava, Slovakia)
Biodegradation of crude oil contamination: from microcosm to in situ bioremediation

P11
Magdalena Urbaniak
(European Regional Centre for Ecohydrologuy of the Polish Academy of Sciences, Lodz, Poland)
Fertilization of agricultural soil with sewage sludge affects its resistome

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P12
Iva Dolinová
(Technical University of Liberec, Liberec, Czechia)
Field study on the dynamics of microbial communities following biostimulation at chlorinated ethenes-contaminated site

GREEN TECHNOLOGIES (BIOREMEDIATION TECHNOLOGIES), MICROALGAE-BASED BIOREFINERIES

P13
Cosimo Masini
(DND Biotech, Pisa, Italy)
Bio-flushing, an innovative technology for in situ soil and groundwater decontamination

P14
Sona Nikolyan
(Yerevan State University, Yerevan, Armenia)
Assessment of the growth characteristics of multiple heavy metal-resistant artrobacter sp. Arts.1-2 strain isolated from artsvanik tailing

P15
Asia Rosatelli
(Università degli Studi di Milano-Bicocca, Milano, Italy)
Crafting a toolbox: unleashing the power of microbiologically activated biochar in bioremediation processes

P16
Sara Muñana González
(Universidad del País Vasco UPV/EHU, Leioa, Spain)
Natural biopolymers as nanocarriers for encapsulation and controlled release of nutrients in bioremediaton systems

P17
Domenico Palatucci
(Depatment of Biology, Federico II University of Naples, Italy)
Halotolerant cyanobacteria strains application for desalination of saline and hypersaline liquids

P18
Michel Chalot
(Université de Franche-Comté, Montbéliard, France)
Biochemical traits, genome sequencing and metabolic modeling of rhizospheric microorganisms isolated at a metal contaminated site

P19
Usharani RK
(Department of Civil and Environmental Engineering, UNESP, SP, Brazil)
Bioremoval of pollutants and recovery of nutrients from wastewater through sustainable ecotechnological approaches

P20
Petra Lovecká
(UCT Prague, Prague, Czechia)
Effect of endophytic microorganisms isolated from wheat seeds on plant growth

P21
Martí Aliaguilla
(LEITAT technological center, Terrassa, Spain)
Electro-bioremediation strategies for the removal of hydrocarbons, BTEX, chlorinated compounds and heavy metals from groundwater

PHYTOREMEDIATION, PHYCOREMEDIATION, MYCOREMEDIATION AND COMPOSTING

P22
Ahmed Abderrafaa Tamma
(Institute of Environmental Engineering, Wrocław University of Environmental and Life Sciences, Wrocław, Poland)
Integrating biodegradable water-absorbing geocomposites and soil amendments for enhanced phytoextraction: A sustainable approach to soil and heavy metal remediation

P23
Arturo Redondo Lopez
(Centro de Biotecnologia y Genomica de Plantas, Madrid, Spain)
Poplar-based phytoremediation of heavy metals enhanced through altered ethylene signaling pathways

P24
Magdalena Urbaniak
(University of Lodz, UNESCO Chair on Ecohydrology and Applied Ecology, Poland)
Pop-bioaccumulation control in cucurbits for safe and healthy food production

P25
Rocío Barros Garcia
(Universidad de Burgos, Spain)
Enhancement of heavy metals phytoremediation potential in phragmites australis through plant growth promotal rhizobacteria (PGPR)s inoculation

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Arturo Redondo Lopez
(Centro de Biotecnologia y Genomica de Plantas, Madrid, Spain)
Poplar-based phytoremediation of heavy metals enhanced through altered ethylene signaling pathways

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Kateřina Němcová
(Institute of Environmental Studies, Faculty of Science, Charles University in Prague, Czechia)
Effects of different organic substrate compositions and soil-to-substrate ratios on the decontamination of aged PAH-polluted soils through outdoor co-composting

P28
Michel Chalot
(Université de Franche-Comté, Montbéliard, France)
Edaphos : advanced mapping, risk assessment and nature-based depollution methods are combined to accelerate the recovery of contaminated soils and ensure that ecological restoration enters mainstream business

WATER POLLUTION & WASTEWATER TREATMENT

P29
Yingrun Chen
(Czech University of Life Sciences Prague, Prague, Czechia)
Enhanced treatment performance and reduction of antibiotic resistance genes of biochar-aeration vertical flow constructed wetland for treating real domestic wastewater.

Tuesday, June 18, 2024

9:00–11:00 **WASTE MANAGEMENT (WASTE VALORIZATION) & WORKSHOP ON CIRCULAR ECONOMY**
Chairpersons: Petra Patáková, Victor de Lorenzo

9:00–9:40
Plenary lecture
Petra Patáková
(UCT Prague, Czechia)
Biotechnological valorization of animal and/or plant waste

9:40–10:00
Igor Yannick Brandão
(Federal University of São Paulo, Brazil)
Bionanomining of copper-based nanoparticles using mine tailings as precursor

10:00–10:20
Christian Hintersatz
(Helmholtz-Zentrum Dresden-Rossendorf, Germany)
Selective recovery of germanium applying agrobactin, a siderophore identified utilizing density functional theory

10:20–10:40
Katarzyna Kowalczyk
(Bio-Rad Laboratories)
Bio-Rad Droplet Digital PCR - your partner in environmental screening

10:40–11:00
Radim Špaček
(CzechInvest)
Technology Incubation - grant scheme to support fresh-born start-ups

11:00–12:00 **POSTER SESSION WITH COFFEE AND SNACKS**

MICROBIAL DIVERSITY AND BIODEGRADATION OF POLLUTANTS

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Paolo Piccolo
(Università degli Studi di Salerno, Fisciano, Italy)
Resilience and response of plant-associated microbiomes to urban wastewater in constructed wetlands: insights from rhizosphere biodiversity analysis

P31
Silvia Leoci
(M3R, Milan, Italy)
Biomolecular markers for the assessment of genetic potential in bioremediation projects

P32
Laura Carrera Ruiz
(Universidad Autónoma de Madrid, Spain)
Design of a synthetic community for the bioremediation of hydrocarbon polluted soil

P33
Tomas Aparicio
(CNB-CSIC, Madrid, Spain)
A genetic tool to foster bacterial evolution at the community level

P34
Joana P. Fernandes
(CIIMAR, University of Porto, Matosinhos, Portugal)
Microbial diversity of CM2C (ciimar microbial culture collection) as a tool for the development of bioremediation applications

P35
Madiha Siddiqui
(University of Antwerp, Antwerpen, Belgium)
Exploration of bacteria for indoor malodor degradation and their integration in commercial applications

P36
Luca Di Stasio
(University of Salerno, Fisciano, Italy):
Micro-biological approach for suistainable urban soil restoration: A case study in Milan

P37
Ryan Thompson
(Newcastle University, Newcastle upon Tyne, United Kingdom)
Investigating the nodule microbiome of a heavy metal stressed Alnus glutinosa chronosequence

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Manuela Tadrosová
(UCT in Prague, Czechia)
The role of secondary plant metabolites in the expression of aromatic ring-hydroxylating dioxygenases in rhodococci

P39
Tomáš Engl
(UCT in Prague, Czechia)
Novel fad-dependent oxidoreductase involved in the catabolism of acetosyringone and co-metabolic degradation of phenaclor and 2,6-dicp

P40
Lýdie Jakubová
(UCT in Prague, Czechia)
Bacterial strains utilizing guaiacylglycerol-β-guaiacylether and their contribution to the decomposition of pollutants

PLASTICS & MICROPLASTICS: FRAGMENTATION, MONITORING, BIODEGRADATION, FATE, RECYCLING

P41
Arely Lechuga Jimenez
(Universidad Nacional Autónoma de México, CDMX, Mexico)
Metaomic analysis reveals key functions in a bacterial community involved in recalcitrant polyether polyurethane degradation

P42
Evdokia Syranidou
(Cyprus University of Technology, Limassol, Cyprus)
The use of microbial cultures with microalgal species for the degradation of bioplastics (PHB and TPS)

P43
Katerina Karkanorachaki
(Technical University of Crete, Chania, Greece)
Development of a soil community for the simultaneous degradation of plastics and pesticides in pilot scale bioremediation experiments

P44
Eliana Musmeci
(University of Bologna, Italy)
Exploring the microbial colonization and biodegradation of biopolyesters in the marine environment under different ocean acidification scenarios: A field study

P45
Rosaria Capuozzo
(University of Bologna, Department of Civil, Chemical, Environmental and Materials Engineering, Italy)
Biodegradation of biopolyesters in an anoxic marine sediment and effects on microbial activities and biodiversity

P46
Caterina Bosticco
(Alma Mater University of Bologna, Italy)
Enhancing bioplastics upcycling through optimized enzymatic depolymerization: A step towards circular recovery methods

TOXICITY & RISK

P47
Davide Righetti
(University of Verona, Italy)
PFAS contamination on environmental matrices and their impact on microbial cells

WASTE MANAGEMENT (WASTE VALORIZATION) & CIRCULAR ECONOMY

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Hubert Byliński
(Gdańsk University of Technology, Poland)
Insights into low-thermal pretreatment combined with enzymatic hydrolysis of food waste: Experimental studies

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Anshu Shaw
(Czech University of Life Sciences Prague, Czechia)
Application of waste filter cakes for growth promotion and production of bioactive substances

P50
Ben Nkapbela
(Thomas Jefferson University, Philadelphia, United States)
Using beer and weed to recover critical materials from agricultural waste

P51
Kristýna Kliková
(UCT in Prague, Czechia)
The contribution of bacillus in facilitating waste concerete recycling through microbially induced calcite precipitation

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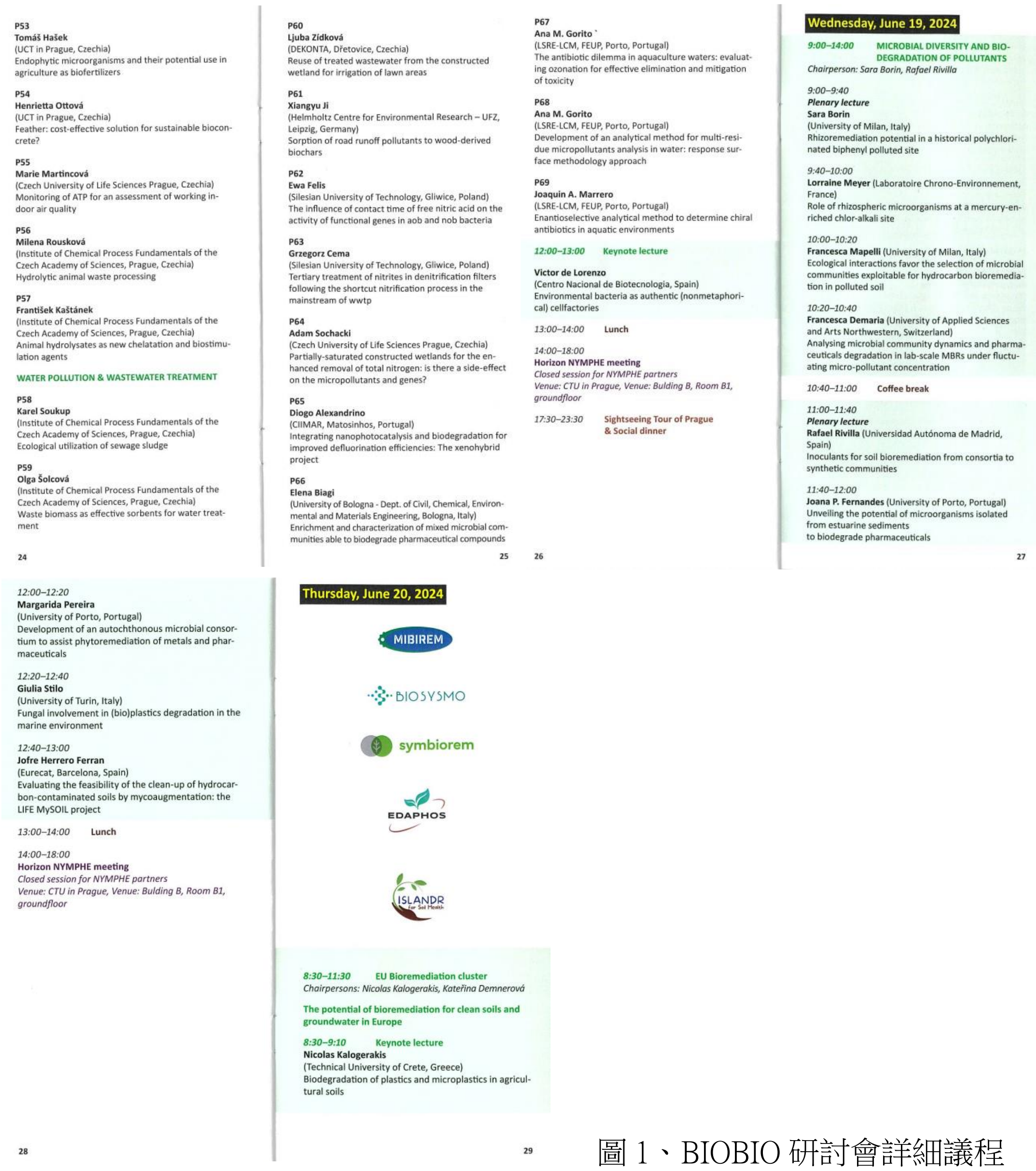
Emma Jones
(University of Bologna, Bologna, Italy)
Valorization of commercial cellulose acetate plastic from eyewear via polyhydroxyalkanoates production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Tomáš Hašek
(UCT in Prague, Czechia)
Endophytic microorganisms and their potential use in agriculture as biofertilizers

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Henrietta Ottová
(UCT in Prague, Czechia)
Feather: cost-effective solution for sustainable bioconcrete?

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Marie Martincová
(Czech University of Life Sciences Prague, Czechia)
Monitoring of ATP for an assessment of working indoor air quality

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Milena Rousková
(Institute of Chemical Process Fundamentals of the Czech Academy of Sciences, Prague, Czechia)
Hydrolytic animal waste processing

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František Kaštánek
(Institute of Chemical Process Fundamentals of the Czech Academy of Sciences, Prague, Czechia)
Animal hydrolysates as new chelatation and biostimulation agents

WATER POLLUTION & WASTEWATER TREATMENT

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Karel Soukup
(Institute of Chemical Process Fundamentals of the Czech Academy of Sciences, Prague, Czechia)
Ecological utilization of sewage sludge

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Olga Šolcová
(Institute of Chemical Process Fundamentals of the Czech Academy of Sciences, Prague, Czechia)
Waste biomass as effective sorbents for water treatment

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Ljuba Zidková
(DEKONTA, Dřetovice, Czechia)
Reuse of treated wastewater from the constructed wetland for irrigation of lawn areas

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Xiangyu Ji
(Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany)
Sorption of road runoff pollutants to wood-derived biochars

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Ewa Felis
(Silesian University of Technology, Gliwice, Poland)
The influence of contact time of free nitric acid on the activity of functional genes in aob and nob bacteria

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Grzegorz Cema
(Silesian University of Technology, Gliwice, Poland)
Tertiary treatment of nitrites in denitrification filters following the shortcut nitrification process in the mainstream of wwtp

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Adam Sochacki
(Czech University of Life Sciences Prague, Czechia)
Partially-saturated constructed wetlands for the enhanced removal of total nitrogen: is there a side-effect on the micropollutants and genes?

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Diogo Alexandrino
(CIIMAR, Matosinhos, Portugal)
Integrating nanophotocatalysis and biodegradation for improved defluorination efficiencies: The xenohybrid project

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Elena Biagi
(University of Bologna - Dept. of Civil, Chemical, Environmental and Materials Engineering, Bologna, Italy)
Enrichment and characterization of mixed microbial communities able to biodegrade pharmaceutical compounds

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P67
Ana M. Gorito
(LSRE-LCM, FEUP, Porto, Portugal)
The antibiotic dilemma in aquaculture waters: evaluating ozonation for effective elimination and mitigation of toxicity

P68
Ana M. Gorito
(LSRE-LCM, FEUP, Porto, Portugal)
Development of an analytical method for multi-residue micropollutants analysis in water: response surface methodology approach

P69
Joaquin A. Marrero
(LSRE-LCM, FEUP, Porto, Portugal)
Enantioselective analytical method to determine chiral antibiotics in aquatic environments

12:00–13:00 Keynote lecture

Victor de Lorenzo
(Centro Nacional de Biotecnologia, Spain)
Environmental bacteria as authentic (nonmetaphorical) cellfactories

13:00–14:00 Lunch

14:00–18:00
Horizon NYMPHE meeting
Closed session for NYMPHE partners
Venue: CTU in Prague, Venue: Bulding B, Room B1, groundfloor

17:30–23:30 Sightseeing Tour of Prague & Social dinner

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Wednesday, June 19, 2024

9:00–14:00 MICROBIAL DIVERSITY AND BIODEGRADATION OF POLLUTANTS
Chairperson: Sara Borin, Rafael Rivilla

9:00–9:40
Plenary lecture
Sara Borin
(University of Milan, Italy)
Rhizoremediation potential in a historical polychlorinated biphenyl polluted site

9:40–10:00
Lorraine Meyer (Laboratoire Chrono-Environnement, France)
Role of rhizospheric microorganisms at a mercury-enriched chlor-alkali site

10:00–10:20
Francesca Mapelli (University of Milan, Italy)
Ecological interactions favor the selection of microbial communities exploitable for hydrocarbon bioremediation in polluted soil

10:20–10:40
Francesca Demaria (University of Applied Sciences and Arts Northwestern, Switzerland)
Analysing microbial community dynamics and pharmaceuticals degradation in lab-scale MBRs under fluctuating micro-pollutant concentration

10:40–11:00 Coffee break

11:00–11:40
Plenary lecture
Rafael Rivilla (Universidad Autónoma de Madrid, Spain)
Inoculants for soil bioremediation from consortia to synthetic communities

11:40–12:00
Joana P. Fernandes (University of Porto, Portugal)
Unveiling the potential of microorganisms isolated from estuarine sediments to biodegrade pharmaceuticals

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12:00–12:20
Margarida Pereira
(University of Porto, Portugal)
Development of an autochthonous microbial consortium to assist phytoremediation of metals and pharmaceuticals

12:20–12:40
Giulia Stilo
(University of Turin, Italy)
Fungal involvement in (bio)plastics degradation in the marine environment

12:40–13:00
Jofre Herrero Ferran
(Eurecat, Barcelona, Spain)
Evaluating the feasibility of the clean-up of hydrocarbon-contaminated soils by mycoaugmentation: the LIFE MySOIL project

13:00–14:00 Lunch

14:00–18:00
Horizon NYMPHE meeting
Closed session for NYMPHE partners
Venue: CTU in Prague, Venue: Bulding B, Room B1, groundfloor

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Thursday, June 20, 2024

MIBIREM
BIOSYSMO
symbiorem
EDAPHOS
ISLANDR

8:30–11:30 EU Bioremediation cluster
Chairpersons: Nicolas Kalogerakis, Kateřina Demnerová

The potential of bioremediation for clean soils and groundwater in Europe

8:30–9:10 Keynote lecture
Nicolas Kalogerakis
(Technical University of Crete, Greece)
Biodegradation of plastics and microplastics in agricultural soils

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圖 1、BIOBIO 研討會詳細議程

具體成效

由於本人關注重點在碳氫化合物降解技術的相關研究上，故具體成效僅條列研討會期間相關議題，經整理可大致分為生物整治柴油污染土壤以及真菌整治。

一. 生物整治柴油污染土壤

1. Inoculants for soil bioremediation from consortia to synthetic communities

此研究在 6 月 19 日由西班牙馬德里自治大學的 Rafael Rivilla 做演講發表，如圖 2 所示，內容提及目前在生物降解的技術應用中，雖然使用單一菌株即可降解多

氯聯苯(PCBs)和總石油碳氫化合物(TPH)等複雜污染物，但若在生物整治的過程中使用菌叢(consortia)策略，污染土壤更能因微生物之間的協同作用建立完整的代謝，許多多環芳烴也可以透過環境中的共同代謝而降解。研究使用的菌叢為自污染場地的樣本中取得，並使用柴油污染物作為唯一的碳/能源，取得能夠在污染物中生長的菌叢進行富集培養。培養出來的微生物以宏基因組學(metagenomic)、宏轉錄組學(metatranscriptomic)和基因組學方法(genomic methods)對菌叢結構進行分析，透過將特定的關鍵編碼 DNA 序列(CDS)來識別降解過程中的活躍族群，進一步確認降解聯苯的主要參與者，並確定了 TCA 循環所有酶的基因編碼。

圖 2、Rafael Rivilla 發表土壤現地菌菌叢的生物整治

細菌可以透過不同的成熟途徑對多環芳烴進行有氧代謝。迄今為止已發現有氧降解烷烴的微生物中的四種途徑，其中兩個經過充分研究的途徑是由烷烴單加氧酶(alkane monooxygenase enzymes)介導的甲基或亞甲基/甲烯基(methylene)的末端或亞末端氧化啟動的，並分別產生一級醇或二級醇，這些醇再進一步被乙醇和乙醛脫氫酶(alcohol and aldehyde dehydrogenases)氧化轉化為脂肪酸，而後進入β-氧化反應；脂肪酸也可經由雙端氧化(biterminal oxidation)在末端Ω甲基氧化後，形成Ω羥基脂肪酸，然後由脫氫酶轉化為二羧酸，再進入 β-氧化反應。烷烴的初始末端或亞末端氧化是透過烷烴單加氧酶(AlkB)，或長鏈烷烴單加氧酶(LadA)進行

的，而透過雙末端氧化途徑形成的Ω羥基脂肪酸則是透過 PYC153 族的細胞色素 P450 進行的，其也可以將末端的烷烴羥基化為一級醇。

由 16S rRNA 定序結果得到 47,306 個序列，可歸屬到 76 個不同的 ASV，rarefaction curve(如圖 3 所示)顯示菌落覆蓋度在 4 萬個序列前就已經飽和，故可以確定定序類群。定序結果如圖 4 所示，在柴油降解菌群中可以觀察到的主要優勢菌為 Pseudomonas、Aquabacterium 與 Chryseobacterium，其他如 Sphingobium、Novosphingobium、Dokdonella、Parvibaculum 以及 Achromobacter 等菌屬亦具有一定相對豐度。

為了確定烷烴降解菌叢中活躍的群體，篩選了柴油降解菌叢的宏基因組 CDS 在降解過程中烷烴酶 AlkB、P450 和 LadA 的分布，結果如圖 5 所示，這些結果與柴油種植群中 Pseudomonas、Aquabacterium 以及 Sphingobium 以及其他 Sphingomonadaceae genera 的相對豐度一致，推測含 AlkB、LadA 和 CYP153 的細菌在烷烴的降解中確實發揮主要作用，或者對特定的烷烴長度或途徑具有特異性。

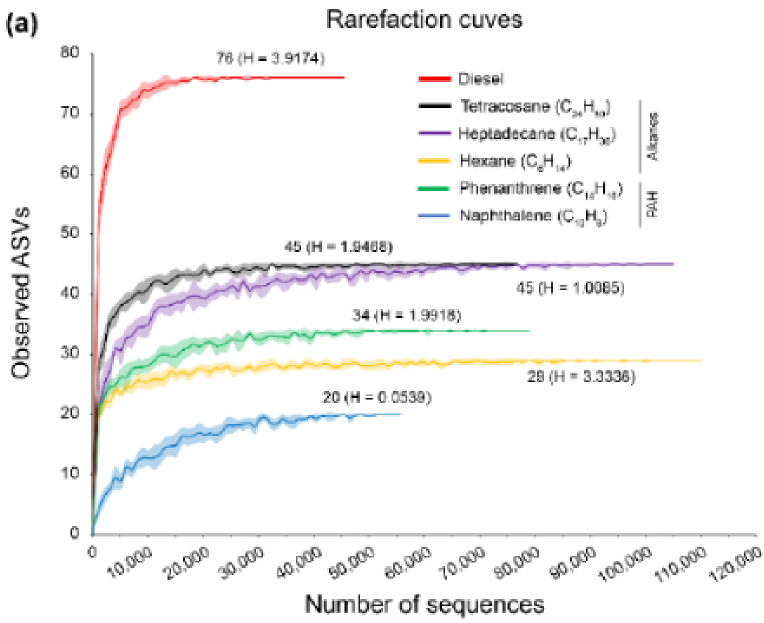


圖 3、rarefaction curve 顯示菌落覆蓋度

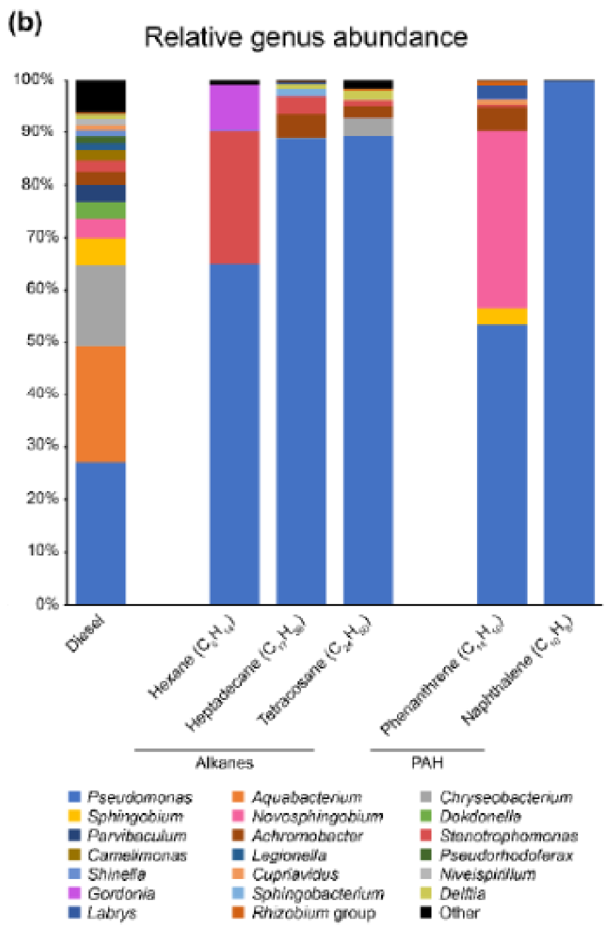


圖 4、培養菌叢菌相分析結果(genus level)

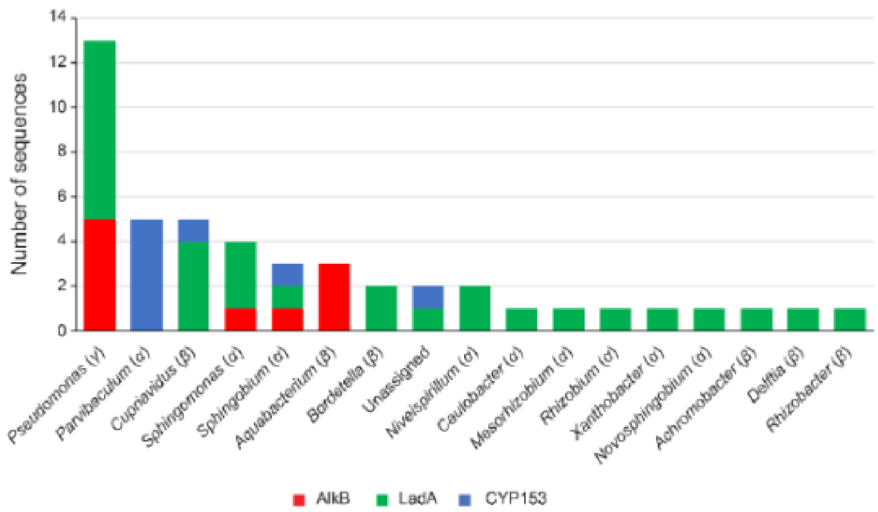


圖 5、柴油降解菌叢烷基酶數量(genus level)

另外，研究也提出在柴油多環芳香烴中，萘及其甲基衍生物含量最多，而萘生物降解是由環羥基化雙加氧酶(NahA)引發的。對柴油降解之宏基因組的分析結果，如圖 6 所示，篩選了 83 種可能的 NahA 的存在。意外的是，這些 NahA 都不是歸屬於 Pseudomonas，甚至不是歸屬於 Gammaproteobacteria (Pseudomonas 所屬門)，而 Gammaproteobacteria 是 PAH 污染場址中的主要優勢菌(在菲或萘中分別佔 59.59 %和 99.75 %)，造成此分析結果的因素很多，推測 Pseudomonas 可能沒有參與柴油 PAH 最初的氧化作用，也可能是定序過程中，宏基因組的深度尚未定出代表性酵素。

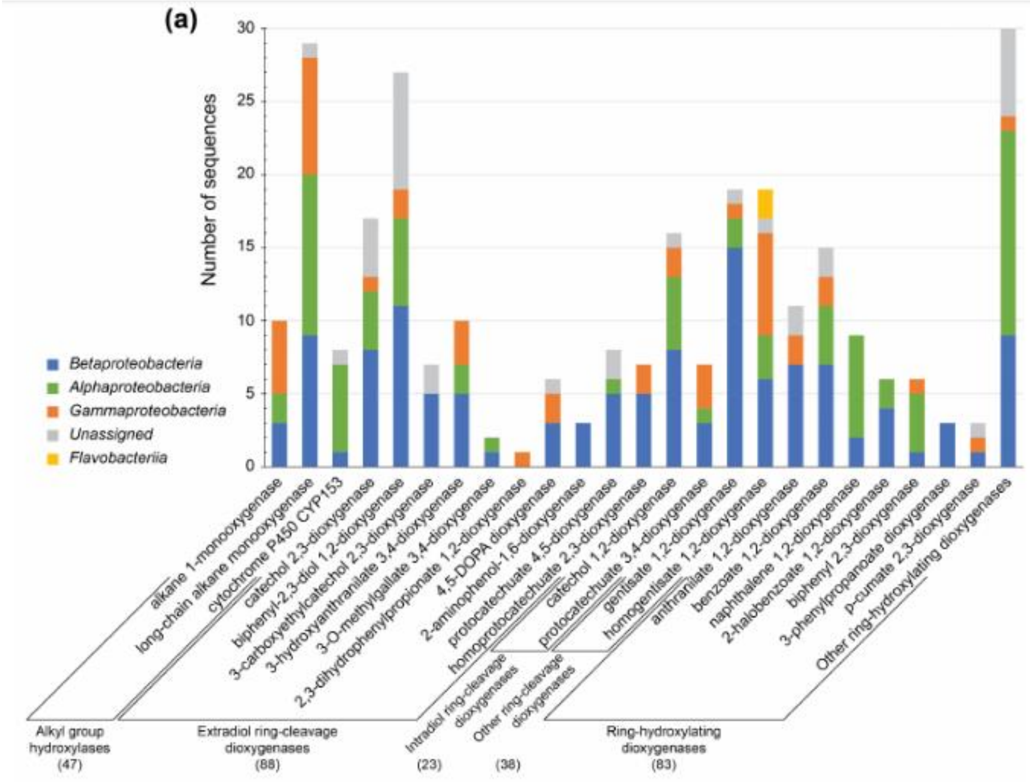
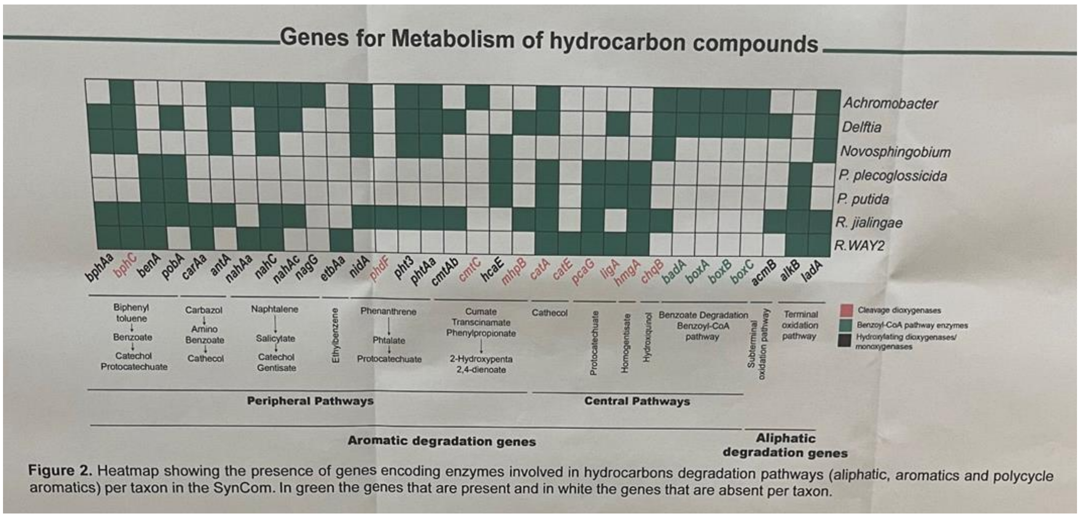


圖 6、菌屬在烷烴、多環芳烴和芳香族代謝途徑酵素

2. Design of a synthetic community for the bioremediation of hydrocarbon polluted soil

Rafael Rivilla 的研究團隊成員 Laura Carrera Ruiz 也做海報發表(如圖 7 所示)，經與其洽詢了解其研究的降解菌叢為 Pseudomonas plecoglossicida、Pseudomonas putida、Rhodoccus jialingiae、Achromobacter aegrifaciens、Delftia acidovorans 與 Novosphingobium silvae 共同作用。令人感興趣的是，研究結果結合資料庫，找出降解菌叢對脂肪族、芳香族和多環芳香族分解的途徑，以及參與降解途徑的酵素基因 (此部分也引起 BIOBIO 評委的興趣，排隊詢問相關研究成果)。另外，海報中也提出降解菌叢 Pseudomonas plecoglossicida、Pseudomonas putida、Rhodoccus jialingiae、Achromobacter aegrifaciens、Delftia acidovorans 與 Novosphingobium silvae 的共同代謝模型與貢獻度，可惜因 Laura Carrera Ruiz 表示此模型是研究室其他學者提出，並不清楚如何製作此模型。



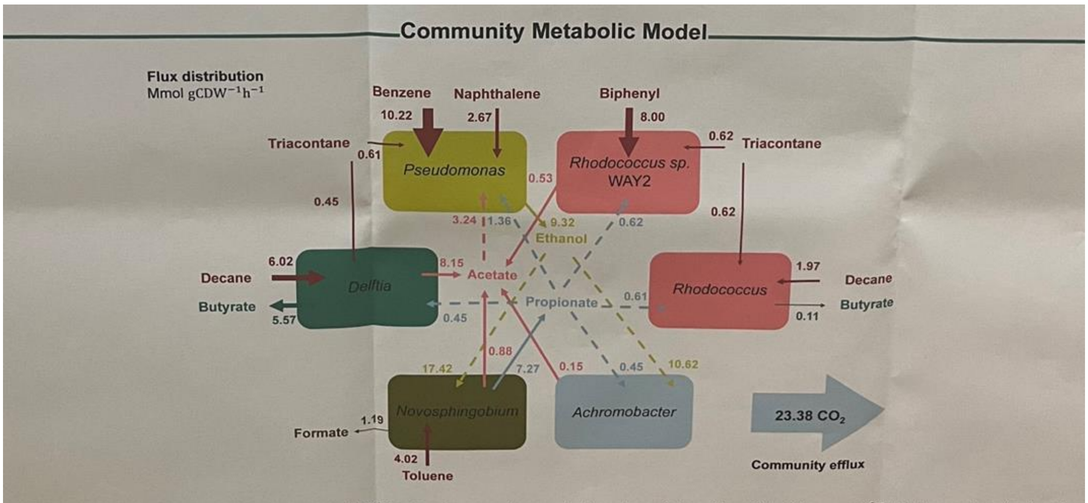


Figure 4. Steady state metabolic activity of the Noblejas SynCom growing on a hydrocarbon mixture. The width of the arrows for uptake reactions (red) and byproducts (green, brown) corresponds to the respective flux values (mmol gCDW^{-1} h^{-1}). For visualisation purposes, the interspecies exchanges are marked with uniform arrow width, regardless of predicted rates. The *Pseudomonas* model is a mixed-bag model representing the two *Pseudomonas* species found in the SynCom.

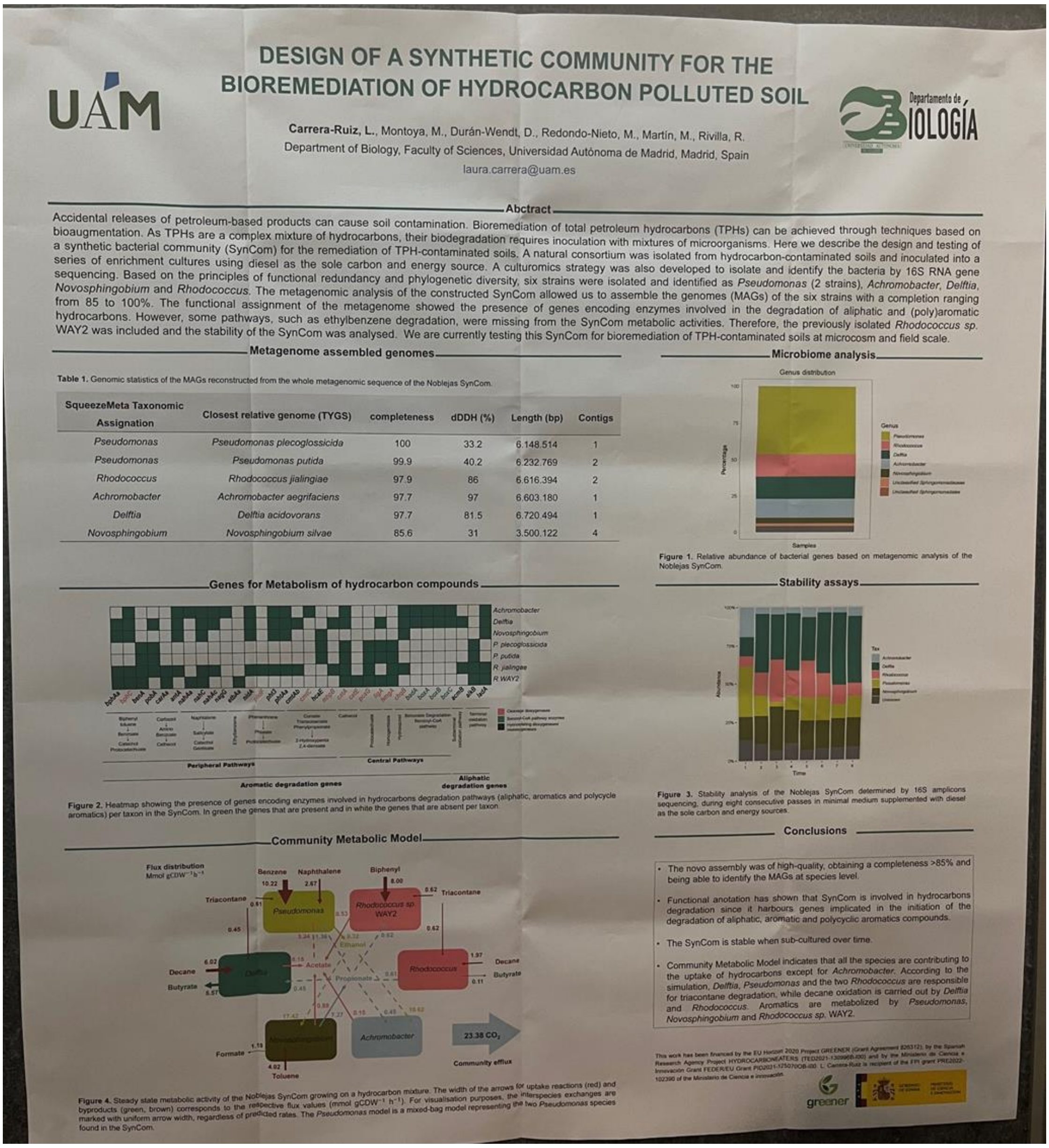


圖 7、生物整治柴油污染相關海報發表-Design of a synthetic community for the bioremediation of hydrocarbon polluted soil

3. Effects of different organic substrate compositions and soil-to-substrate ratios on the decontamination of aged PAH-polluted soils through outdoor co-composting

在海報發表中，博士生 Kateřina N ě mcová研究在不同有機基質成分下，以堆肥作為整治 PAHs 污染土壤的生物處理技術。經與 Kateřina N ě mcová洽談了解到，堆肥過程中需要考慮的參數，包括初始顆粒大小、營養物質、氧氣含量、水分含量、pH 值和溫度等；此外，堆肥過程中產生的高溫，也有助於透過降低污染物的黏性，進一步提高生物可用性來增加生物降解效率。生物作用方面，除了代謝降解污染物的機制，某些微生物物種在堆肥過程中可成產生的生物表面活性劑，例如鼠李醣脂，也可以透過增加有機污染物的溶解來增強生物降解作用。

雖然堆肥來源眾多，但經試驗期間研究成果證明，有機底物的組成雖然對 PAH 的降解速率有影響，但並沒有顯著影響 PAH 的最終降解程度。

經過 680 天以上的共堆肥後，所有試驗組的 PAH 降解率皆大於 95 %，並且中、低分子量的 PAH 幾乎已被完成降解，而 5 環及以上高分子的 PAH 也有 54 %~79 % 的降解率。菌相分析顯示所有樣品中均檢測到具有 PAH 降解潛力的屬，主要優勢菌為 Proteobacteria、Firmicutes 與 Actinobacteria (phylum level)。另外，經毒性測試結果說明，最終堆肥幾乎不存在任何毒性。

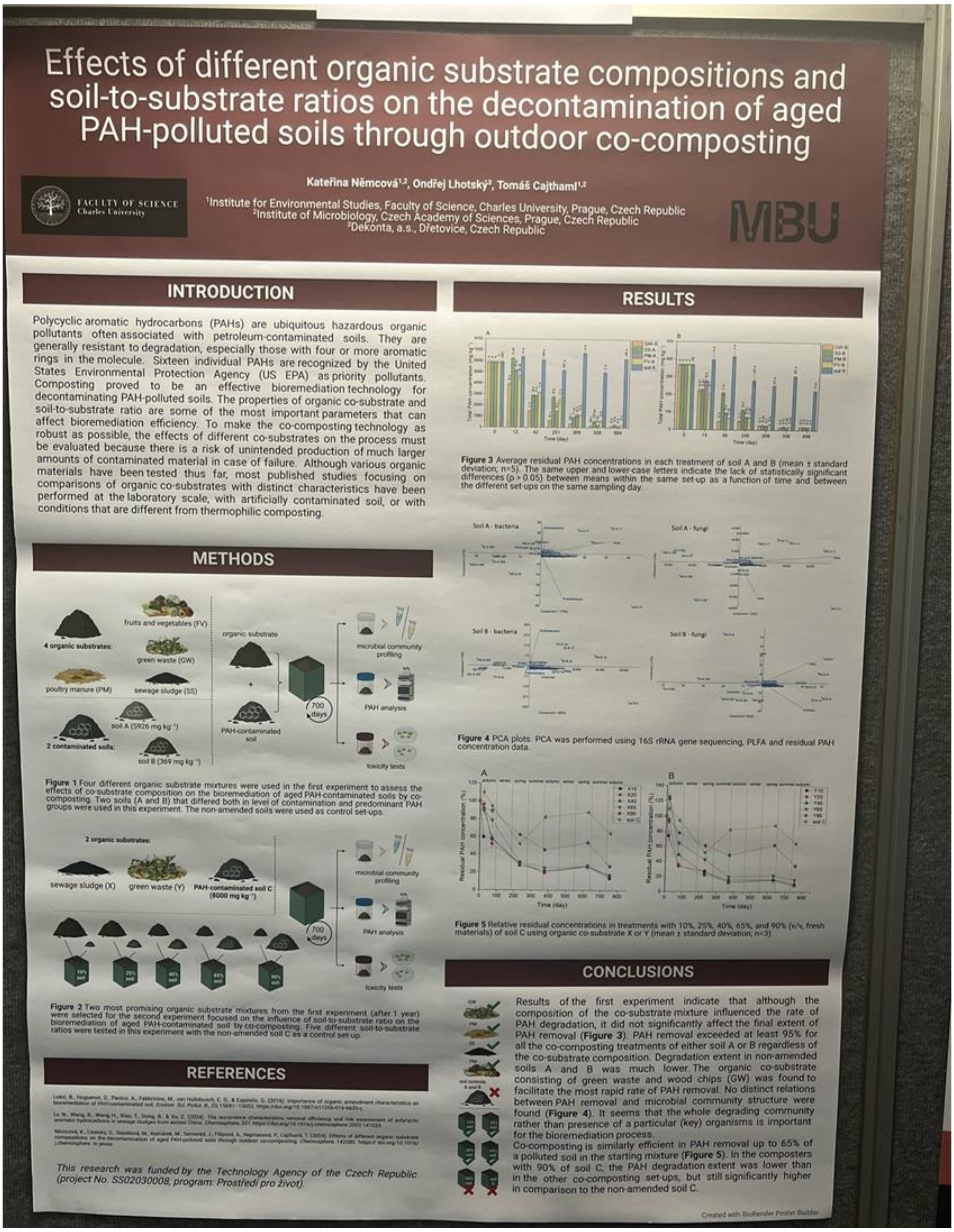


圖 8、生物整治柴油污染相關海報發表- Effects of different organic substrate compositions and soil-to-substrate ratios on the decontamination of aged PAH-polluted soils through outdoor co-composting

4. Assessment of the bioremediation potential of soil contaminated with hydrocarbons from a fuel spill

因作者 Jesus Berganza 不在現場無法及時討論，經檢視海報發表內容發現其在 M9 培養基中，以碳氫化合物作為碳源篩選出現地分解菌 Pseudorthrobacter sp.、Nocardioides albus、Lutelbacter jiangsuensis、Rhococcus erythropoils、Rhococcus electrodinphilus、Gordonia amicalls 與 Achromobacter pulmonis 等 7 株菌，分離出來的菌株個別做油品污染降解試驗，發現 Gordonia amicalls 降解率最佳，12 天降解率超過 80 %，Rhococcus electrodinphilus 次之，降解率約為 50 %，Rhococcus erythropoils 降解率只有接近 40 %，顯示 Rhococcus 屬菌株具有油品污染降解能力，但菌株表現亦存在降解效率的差異。

作者並將單離出來的現地分解菌做 4 種組合，分別是 Rhococcus erythropoils + Gordonia amicalls、Pseudorthrobacter + Gordonia amicalls、Pseudorthrobacter + Rhococcus erythropoils，以及 Pseudorthrobacter + Rhococcus erythropoils + Gordonia amicalls，令人意外的是，組合菌的降解效率皆有大幅提升，在 12 天的試驗中，表現最佳的組別為 Rhococcus erythropoils + Gordonia amicalls，降解率約為 86 %，而表現最差的組別為 Pseudorthrobacter + Rhococcus erythropoils，也有約 78 %的降解效率。

由實驗結果成果表明，使用降解菌叢(consortia)策略，有助於提升油品污染物的生物降解作用。

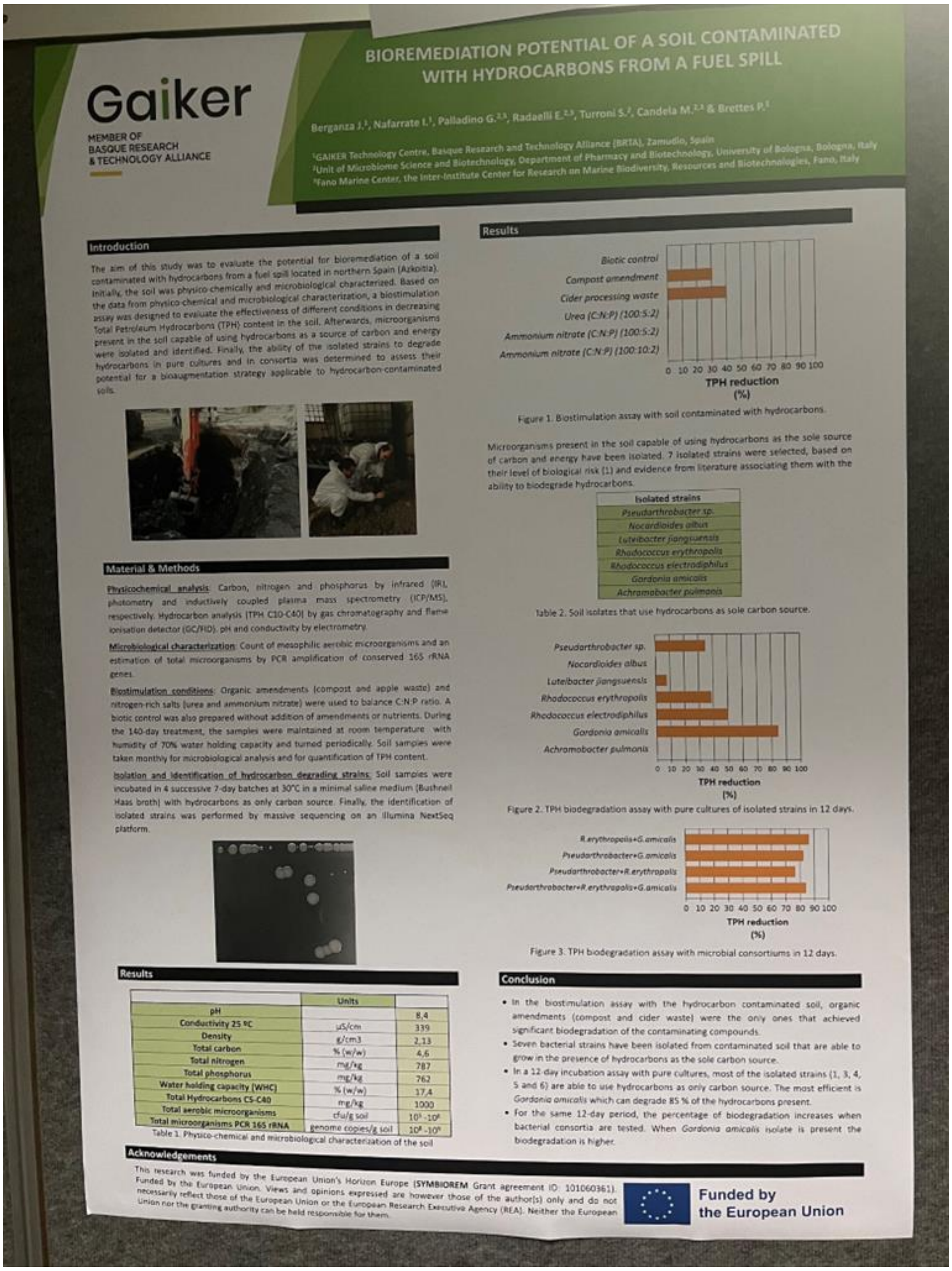


圖 9、生物整治柴油污染相關海報發表- Assessment of the bioremediation potential of soil contaminated with hydrocarbons from a fuel spill

二. 真菌整治

西班牙研究機構 Eurecat 的 Jofre Herrero Ferran 在 17 日與 19 日分別發表 Guidelines for Mycoremediation - Replicability to Boost Implementation，與 Evaluating the feasibility of the clean-up of hydrocarbon-contaminated soils by mycoaugmentation: the LIFE MySOIL project，闡述以真菌作為微生物的主體，整治碳氫化合物污染土壤的可行性。以真菌作為整治污染物的媒介，其優點在於真菌的菌絲體可以構築成網路(mycelial network)，讓細菌可以主動或被動地沿者菌絲移動，進而促進細菌在土壤中的分散，更積極的機制涉及菌絲體網路透過細胞質流(cytoplasmic flow)中富含脂質的囊泡(lipid-rich vesicles)，透過其菌絲結構吸收並主動轉移污染物和營養物質。無論機制如何，菌絲體網絡都提供了增加碎烴細菌和疏水性污染物之間接觸頻率的機會，從而減輕與污染物的低生物利用度相關的問題；此外，真菌會分泌活性物質，其中以表面活性劑和真菌酶尤為相關。

圖 10、Jofre Herrero Ferran 發表真菌整治碳氫化合物場址

試驗土壤採自現地污染場址的土壤 (試驗土壤性質如圖 11 所示，初始污染濃度為 6990 mg/kg)，並混入農業食物鏈的廢蘑菇基質或 UNITUS 實驗室的真菌接種物，探討生物可處理性。實驗設計流程為先做適應性試驗(Adaptablity tests)與微觀生態系試驗(Microcosm experments)，確認微生物能在污染環境中生存，接下來逐步放大模場試驗規模，自 5 公斤的真菌生物堆開始，進一步做到 1 立方公尺的規模，最後如圖 12 所示，在 Municipality 市進行了每堆 50 立方公尺的模場試驗。

模場試驗現場配置 7 個偵測器，監測包含溫度、濕度在內的現場環境。真菌生物堆的土壤濕度約在 60~70 %，設置時須注意土壤通氣性，適度補充基質以維持真菌生物堆有足夠的營養，並且溫度控制在 20~30 ℃之間。

試驗土壤並且採樣進行分析菌相組成，細菌分析 16S rRNA v3-v4 片段，真菌則做 ITS2 rRNA 分析。由分析結果可以觀察到真菌生物堆具有生物多樣性，並且細菌與真菌能良好的共存於環境之中。

最後，Jofre Herrero Ferran 強調良好的規劃應用廢蘑菇基質，屬於當地有機廢棄物的再利用，不只解決農業廢材，同時也創造了循環經濟。

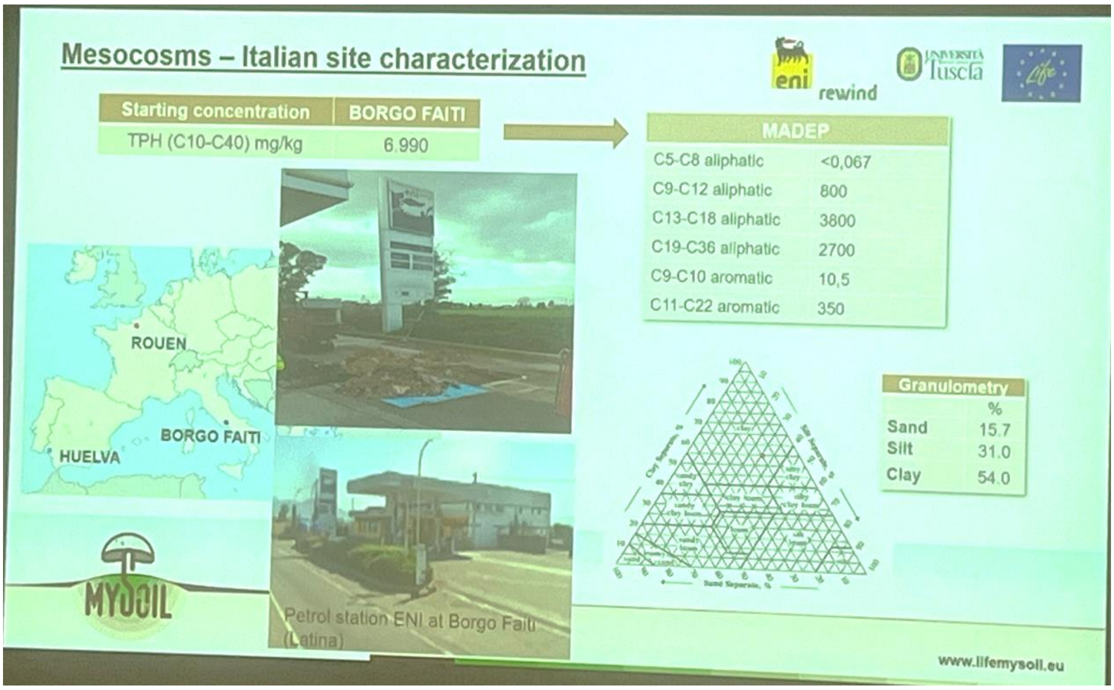


圖 11、真菌試驗土壤性質

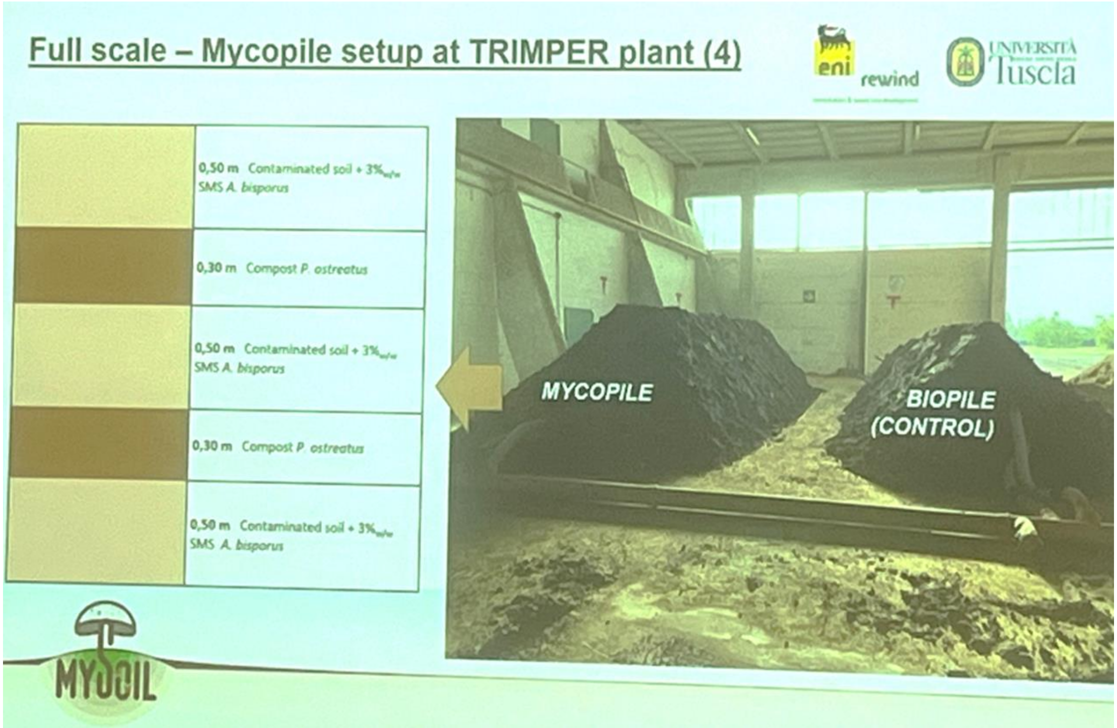


圖 12、模場試驗的真菌生物堆

心得及建議

經過疫情的考驗，久違地能再次參加大型國際研討會，難掩個人激動的心情。在研討會會場見證了許多來自歐洲各國生物專業領域的學者，談著就算在生物整治的領域裡，也存在著許多領域分支，各分支領域間的專業壁壘，平時難以觸及，透過本次研討會也能窺見一二。這 5 天的研討會每天皆定有不同發表的議題，可以看到每天參加的專家學者基本上是不同批人，足見生物整治領域之深。

雖然各研究主題有彼此交流對實驗的見解與建議，還是發現特定領域裡，許多大學研究室或研究機構都有深度合作，共同開發生物整治技術，因此，在幾場發表會裡可以看見時間尺度大、跨領域(如結合現場操作與資料庫分析應用)的研究內容，這部分或許值得吾人效仿，與不同專業領域的研究室或機構合作，進一步拓展研究的深度。

經歷這次國際學術會議的洗禮以及與學者們的交流，見識各地學者前瞻性的研究成果，更加確知個人在此研究領域上並不孤獨，此前對分子生物應用有過一些規劃，不曾想在會場看到已有相似的研究發表，期待不日可以師法這些研究方法，做出本土化應用，初步估計可以實際應用的方向包含先參考現地菌菌相分析資料再進行篩菌、查找篩出菌的代謝途徑與相關基因組，以及參考篩出菌資料再進行組合試驗等。經過這次經驗，也期待以後再有機會出席國際學術會議，

附錄

研討會期間紀錄

圖 13、BIOBIO 研討會舉行地點- 國家技術圖書館

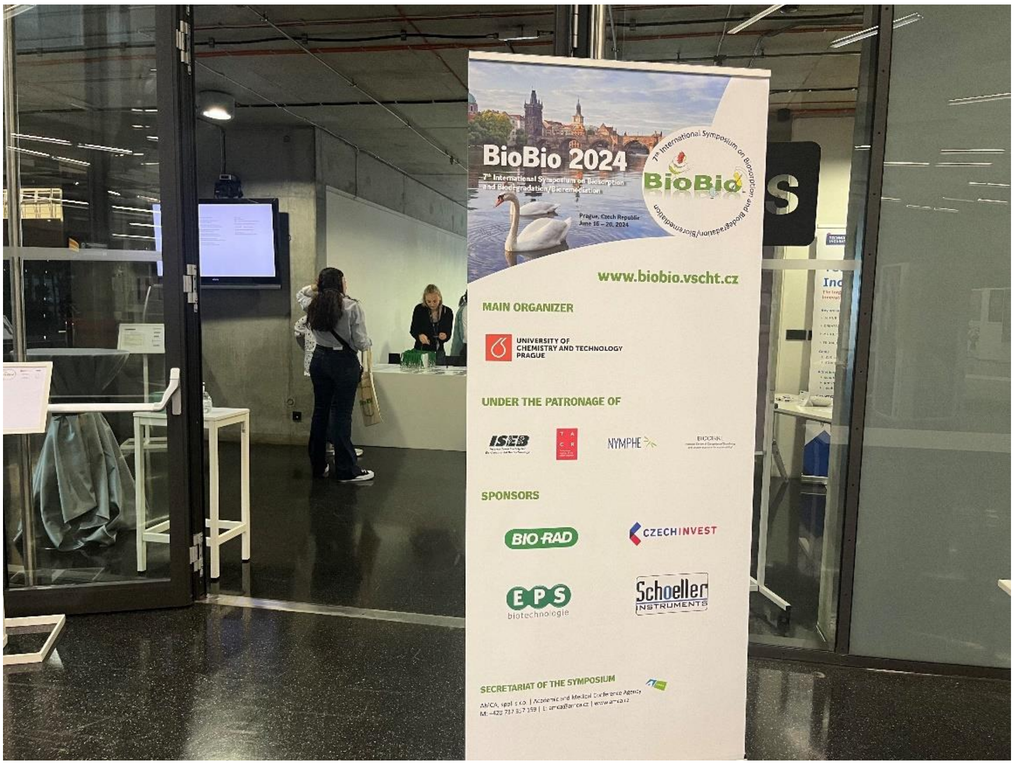


圖 14、會場內柏林廳註冊櫃台

圖 15、出國人員註冊照片

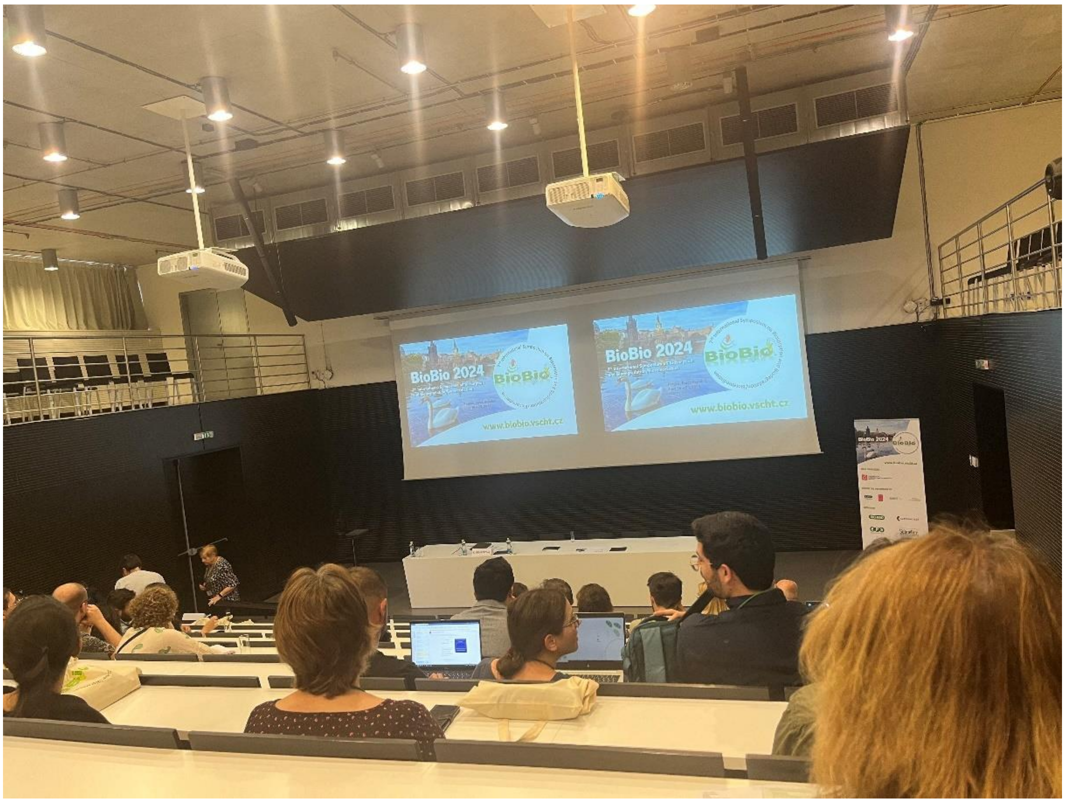

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圖 16、會場一隅

圖 17、海表發表會場