

AquaConSoil in Prague provides ideal setting to showcase EiCLaR

The EiCLaR project was very active at the AquaConSoil conference held between 11th-15th September 2023 in Prague. In addition to delivering individual research presentations on technical progress throughout the week, a special EiCLaR-focused session was held on 14th September and this session is the focus of this article.

EiCLaR Special Session

The special session presented two sustainability assessment case studies of enhanced bioremediation across Europe and was chaired by Nicola Harries, CL:AIRE.

Paul Bardos from R3* introduced the EiCLaR project and gave an overview of the four technologies being developed:

- Electro-nanobioremediation (ENB)
- Monitored Bioaugmentation (MBR)
- Bioelectrochemical Remediation (BER)
- Enhanced Phytoremediation (EPR)

He explained the rationale for the sustainability assessment case studies; their purpose being to compare EiCLaR technologies with pre-existing alternatives on real sites.

The basis for comparison was qualitative and split into three parts: technical, cost effectiveness and sustainability. The assessments all followed a common protocol and were compliant with ISO 18504:2017.

Steffen Hertle from DVGW* explained how MBR was being modified to enhance the degradation of

*Full names of project partners are given on page 5.



Steffen Hertle explaining MBR.

chlorinated solvents and Petr Kvapil, Photon Water Technology described the ENB process and how nanoscale zero-valent iron was being combined with electrokinetic inputs to improve efficiency.

Two sustainability assessment case studies were then presented:

NAM Site Case Study

Marta Popova and Samuel Wildemeersch, both from SPAQUE, introduced the Nouveaux Ateliers Mécaniques (or NAM) site in the Walloon Region, Belgium. It was a former mechanical factory active between 1907 to 2002. Rehabilitation works on site were performed between 2008 and 2014. Since 2020, SPAQUE is carrying out environmental monitoring of the groundwater on the site. An additional intervention was required taking into account the values of the chlorinated solvents present in the groundwater. A qualitative

CONTENTS

⇒ EiCLaR at AquaConSoil	1-2
⇒ Project Meeting in China	2
⇒ Interviews with the Partners	3
⇒ Technology Updates	4
⇒ Keeping Informed	5
⇒ Project Partners	5



Marta Popova describing the NAM site.

comparison took place between three EiCLaR remediation technologies (ENB, MBR with *in situ* flushing, MBR with direct push injection) and a well-established alternative (biostimulation for dehalorespiration).

The comparison ranked MBR with direct push injection high for sustainability and cost and second on technical performance. It was therefore selected as the most appropriate technology.

Overall, the feedback on the assessment process was very positive. SPAQUE held meetings and discussions with the technology developers and found the qualitative assessment easy to undertake and it facilitated the decision-making process for selecting a technology to be deployed on site.



Höchst Industrial Site Case Study

Horst Herzog and Christine Ziegler, Infraserv described the Höchst Industrial Site in Frankfurt, Germany. In 1863, the site was used for dye manufacturing and 160 years of industrial use has resulted in a large, complex site where now 90 companies operate. The site has also been heavily investigated (with over 9000 drillings) and there is an excellent understanding of the contamination beneath the surface.

For the purpose of the case study, the focus was on remediation of chlorinated solvent contamination in the southern area of the site using four technologies - complete dehalorespiration with direct push application of hydrogen release compound (CD), sequential anaerobic / aerobic with direct push application of peroxide for aerobic (SEQ-DP), sequential anaerobic / aerobic with existing monitoring wells used for groundwater oxygenation (SEQ-GW) and no additional intervention (NAI).

The comparison of options ranked SEQ-GW highest on technical performance, particularly in relation to risk management and time, which were considered most important to Infraserv. SEQ-DP ranked more favourably over sustainability and cost, however, SEQ-GW was considered the overall best option.

The feedback on the assessment process was that it was easy to understand and implement and led to guided discussions to consider and rank the reported aspects efficiently.

Whole-Project Meeting in China

In November 2023, the Chinese partners led by Prof. Xin Song of Institute of Soil Science, Chinese Academy of Sciences (ISSAS) hosted their European counterparts at the first whole-project EiCLaR meeting in China. Previous planned meetings were postponed due to the Covid-19 pandemic, but this trip gave an ideal opportunity to make up for lost time.

The busy programme started on 6th November in Nanjing at ISSAS, where three days of meetings were used by project participants to discuss work package progress, share ideas and plan the next phases of work.

On 6th November the team came together for an internal meeting to introduce themselves and provide a brief introduction of the different work packages and how the European and Chinese partners work interrelate.

On 7th November, the EiCLaR team started the official progress meeting in the presence of the National Natural Science Foundation of China (NSFC) expert panel members. Prof. Frederic Coulon, Cranfield University was present representing the EiCLaR Technical Advisory Board, and Prof. Yongguan Zhu of Institute of Urban Environment, Chinese Academy of Sciences moderated the NSFC panel of experts. A series of presentations was provided for all the work packages with emphasis on the most recent results and what is planned next. Discussion and opinion sessions were provided throughout the day by the expert panel members. Closing remarks were



EiCLaR project partners at the whole-project meeting in Nanjing (November 2023).

provided by Prof. Yongguan Zhu and Prof. Fred Coulon to congratulate the consortium on their progress and to provide their thoughts on how they would like to see the project moving forward. Prof. Xin Song and Prof. Timothy M. Vogel provided closing remarks on behalf of the European and Chinese Consortium.

On the 8th November, the team came together for an internal meeting moderated by Prof. Xin Song and Prof. Timothy M. Vogel to allow the team to have internal discussions of specific work package elements and to start to plan the next phases of work.

On the 9th November, the group travelled two hours from Nanjing to Zhangjiagang to visit one of the technology demonstration sites. Here, the European partners had the opportunity to understand how their Chinese partners had been carrying out a series of field trials on a former chemical site. The site is currently

demonstrating ENB and EPR to treat contaminated soil and groundwater. The site visit provided the European partners the opportunity to understand more fully how their Chinese partners are approaching their work on site and to share expertise and knowledge. The European and Chinese partners took the bus to Shanghai.

On 10th November, there was a visit to both the Shanghai Jiaotong University environmental microbiology laboratory and the CSEEC Eco-Environmental Engineering Research Center before a boat trip excursion and dinner on the Huangpu River.



On site at the Zhangjiagang technology demonstration site.



Interviews with Project Partners

Nicola Harries from CL:AIRE has been conducting a series of interviews with members of the EICLaR team to find out a bit more about their backgrounds and how they got to where they are now.

First up was Prof. Timothy M. Vogel from the Université Claude Bernard Lyon1 in Lyon (CNRS) in France, who is the lead coordinator of the project.



Nicola interviewing Timothy.

My background is a little bit unusual in the sense I've been living in France for 30 years, but actually come from California in the US. It's interesting to reflect on your own journey as when I started out my studies in the US, you had a lot of flexibility and I ended up with degrees in geology and oceanography. Then after my undergraduate education I worked as an oceanographer researcher for the US Geological Survey. So it was not in the polluted soil bioremediation area at that time, but you know how sometimes it's a combination of interest, chance and opportunity that kind of drives you forward.

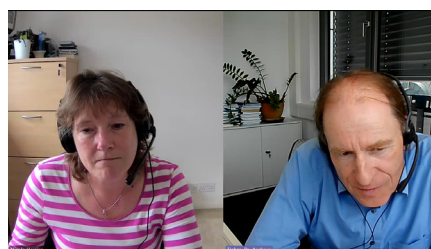
While I was at the US Geological Survey, I'd been doing work on natural organic processes and interested in how much that pertained to the pollution that we were putting into the environment. So I went back to Graduate School and did a Masters and PhD in Environmental Engineering. The PhD focused on the biological degradation and microbial degradation of chlorinated solvents which at that time weren't considered to be biodegradable. Chlorinated solvents were used as cleaners for degreasing and in the automobile industry. Dry cleaners also used them for cleaning until quite recently and they weren't considered particularly toxic. Obviously as science developed and new toxicology knowledge is acquired then people started worrying about them, in the same way as PCBs

and PFAS as more recent examples. But at the time, chlorinated solvents were the case and I was able to show in the mid-1980s that they were broken down, degraded by bacteria that live in the absence of oxygen - anaerobic bacteria, which was quite a novel finding at the time. Obviously since then people have developed that knowledge into actual site cleanup and remediation technologies, but for the last 40 years I've been working on the degradation of pollutants by microorganisms and the use of those in the environment to clean up polluted sites.

I became a professor at the University of Michigan, got tenure in the US system after six years and then you go on to something else. At that point, I was looking for a place to do a sabbatical and got contacted by a large multinational company that no longer exists in France, and so in 1992, my wife and I moved to France. I worked for eight years for the company and then the company broke up into pieces and I went back to academic life at the Université Claude Bernard Lyon1 in Lyon in 2000, in the Department of Biology. So, I'm a professor of biology without actually having a degree specifically in biological fields. But I do biology. I actually do molecular ecology, which means I look at the DNA in organisms to understand what they're doing and how active they are, but related to pollution degradation, among other things.

So that's kind of a long story of how I got to France!

Nicola's second interview was with Professor Andreas Tiehm, Head of the Department of Water Microbiology at TZW in Germany. Within the EICLaR project, Andreas is a work package leader focusing on bioaugmentation.



Nicola interviewing Andreas.

My background is in biology in general, dealing with plants, with animals and also with microorganisms. That was interesting, but there was one point many years ago when I realized that bacteria can degrade those compounds that are toxic to humans. So, this means what is a problem for us is a delicious food for bacteria. This was very fascinating for me and so I decided to study this topic in more detail. This was also the reason why I had to move at that time from the University of Hamburg to the University of Karlsruhe, because there were not so many professors available that were teaching biodegradation and there was one professor, Ludwig Hartmann, who was a specialist for wastewater treatment and he developed lectures where people with biology and engineering backgrounds could attend.

I learned a lot about pollutant biodegradation and wastewater in the beginning. Then, I moved to the area of contaminated sites remediation and, of course, I was very interested in biodegradation processes. So, I did my PhD about biodegradation of polycyclic aromatic hydrocarbons (PAHs) and how to improve the bioavailability of these contaminants. After working here for some years, I moved back to the University of Hamburg to do wastewater research, in particular looking at excess sludge disintegration to improve anaerobic stabilisation.

After five years, I had an offer from the Water Technology Centre (TZW) in Karlsruhe to continue investigating the biodegradation of pollutants at contaminated sites. Then, I also started to give lectures at the Karlsruhe Institute of Technology where I've been giving lectures for more than 10 years and have been appointed as a so-called honorary professor for doing this.

I've now been at TZW for 24 years and we undertake research projects funded by both the government and the water companies related to water quantity, water distribution and water quality, including microbiological parameters.



Update on EiCLaR Technologies

Electro-nanobioremediation (ENB)

USTUTT and ISSAS are leading the work on ENB with involvement from TUL, PWT, DVGW, R3, EKO, DSBP and SJTU. For background on ENB visit the EiCLaR website - eiclar.eu/technologies/enb.

Work progress

PWT is testing the effectiveness of the ENB technology on a pilot project in Spain. During a recent site visit, systems were checked and adjusted for monitoring physical-chemical parameters and direct current potential. The polarity of selected power electrodes was changed from anodes to cathodes and vice versa. The position of electrodes in two wells was also adjusted.



ENB pilot tests in Spain.

Bioelectrochemical Remediation (BER)

ECL, DVGW, ZIU and CUG are leading the work on BER with support from USTUTT, BOSS, EKO, R3 and DSBP. For background on BER visit the EiCLaR website - eiclar.eu/technologies/ber.

Work progress

USTUTT has set up an upscaled Microbial Fuel Cell experiment to help gain insights into the development of BER technology and a field test is planned for 2024.



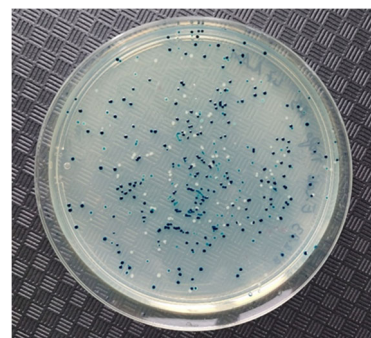
Microbial fuel cell experiments at USTUTT.

Monitored Bioaugmentation (MBR)

DVGW is leading the work on MBR in collaboration with ECL, BOSS, USTUTT, EKO, R3, DSBP and ZJU. For background on MBR visit the EiCLaR website - eiclar.eu/technologies/mbr.

Work progress

DVGW has been developing a method for the analysis of aerobic metabolic TCE-degrading organisms (see right). White colonies have successfully implemented a recombinant plasmid with the target gene into the cells. Then, amplification of the recombinant plasmids was carried out through incubation of a suitable colony.



Isolation of bacteria with target genes.

Column experiments have also been conducted at DVGW to investigate spatial and temporal spread of aerobic metabolic TCE-degradation based on different bioaugmentation approaches.

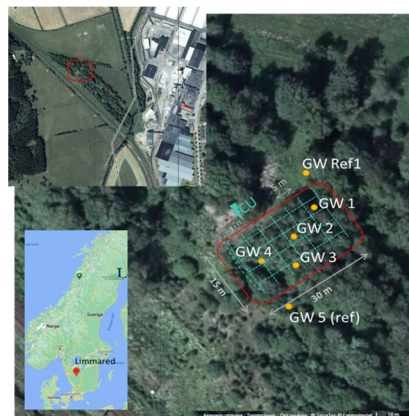
Enhanced Phytoremediation (EPR)

LTU and GIG are leading the work on EPR with support from SERPOL, ECL, EKO, R3, DSBP and ISSAS. For background on EPR visit the EiCLaR website - eiclar.eu/technologies/epr.

Work progress

All laboratory and medium-scale outdoor experiments of electrokinetically-EPR of PAH and arsenic-contaminated soil from Sweden are completed.

Pilot-scale field tests in the south of Sweden applying EPR to soil contaminated with wood impregnation chemicals continue. Groundwater sampling frequency has decreased from monthly to quarterly, while analyses were complemented with Oxy-PAH analyses. The experiments will continue until summer 2024.



Area

30 x 15 m (450 m²)
Electrode depth: 2 m
Total treated volume:
900 m³; >1000 t

5 x 5 m electrode grid
(28 electrodes)

4 GW wells inside
2 GW wells outside
(references)

GW well depth 2.2-2.5 m

As >1000 mg/kg
PAH ca 39 g/kg

Pilot-scale field experiment in south of Sweden.



Keeping Informed and a Fond Farewell

The best place to keep informed about EiCLaR's progress, activities and events is to visit our new and improved website at www.EiCLaR.eu. Here you can find a two-minute video (see below) which sets the context for the project along with more information about the four technologies being developed.

EiCLaR in a nutshell



Short project introductory video.

Alternatively, you can get updates via [LinkedIn](https://www.linkedin.com/company/eiclara/) or WeChat (available in China) or by contacting Timothy M. Vogel at CNRS via email: vogel@univ-lyon1.fr

We want to say thank you and good luck to Maria Tovilla Coutino (see right) who has been project managing the EiCLaR project for the past 18 months and has recently moved on to a permanent position as an EU Project Manager at the University of Lyon. Maria's energy and enthusiasm will be sorely missed.

The next EiCLaR Newsletter will be published in Spring 2024 and will provide further updates on the EiCLaR technologies and the wider project work.



Maria at AquaConSoil 2023.

Project Partners

CNRS	French National Centre for Scientific Research, France
R3	r3 Environmental Technology Ltd, UK
DVGW	DVGW-Technologiezentrum Wasser, Germany
USTUTT	VEGAS: Research Facility for Subsurface Remediation, University of Stuttgart, Germany
PWT	Photon Water Technology s. r. o., Czech Republic
LTU	Luleå University of Technology, Sweden
TUL	Technical University of Liberec, Czech Republic
SPAQUE	SPAQUE, Belgium
CL:AIRE	CL:AIRE, UK
DSBP	Dutch Sino Business Promotions, The Netherlands
BOSS	BoSS Consult GmbH, Germany
SERPOL	SERPOL, France
EKO	EKOGRID Oy, Finland
ISSAS	Institute of Soil Science, Chinese Academy of Sciences, P. R. China
SJTU	Shanghai Jiao Tong University, P. R. China
ZJU	Zhejiang University, P. R. China
CUG	China University of Geosciences, P. R. China
GIG	Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, P. R. China

