EiCLaR

NEWSLETTER

SUMMER 2024

Enhanced and Innovative *In Situ* Biotechnologies for Contaminated Land Remediation

Collaboration is key as EiCLaR project enters final phase

CONTENTS

Project Meeting

The most recent EiCLaR project meeting was held in Liberec, Czech Republic from May 14 to 15. Kindly hosted by local partners, TUL* at the Institute for Nanomaterials, Advanced Technologies and Innovation, Chinese and European partners were joined by Pierre Matz (Solvay) from the project Stakeholder's Board.

The meeting provided the opportunity for information sharing and facilitated further cooperation and communication regarding the progress of project research and development. More specifically, discussions centred on the technical research, case studies, pilot sites and market promotion. On May 16, some Chinese and European project partners also had an excursion to Straz Pod Ralskem, near Liberec, to understand about chemical mining of uranium.

Project team in Liberec.

Developing Research Linkages

Following the project meeting in Liberec, Prof. Xiaojun Zhang from SJTU visited TZW in Karlsruhe, Germany. Aside from a tour of the laboratory, possibilities of cooperation during the remaining duration of the EiCLaR project, as well as new opportunities for further collaboration between SJTU and TZW in the coming years were discussed.

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

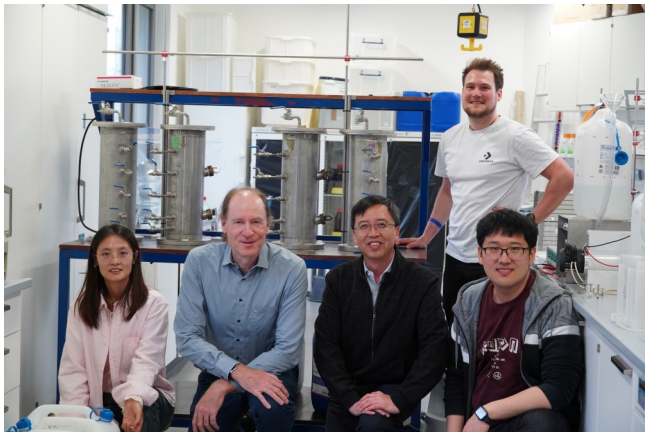
Start of Research Visit

As part of their PhD-theses, Zhengtao Li (ZJU) and Zhuanxia Zhang (ISSAS) will spend 6 months and 12 months respectively at DVGW:TZW in Karlsruhe, Germany. They will conduct research focusing on the aerobic metabolic degradation of chloroethenes investigated in Work Package 2 of the EiCLaR project.

Zhengtao will focus on the effects of heavy metals on the aerobic degradation of chloroethenes, expanding his previous work investigating the effects of heavy metals on reductive dechlorination of chloroethenes.

Zhuanxia's focus will be set on to the delivery of oxygen into anoxic environments to stimulate the aerobic metabolic TCE degradation under varying oxygen concentrations using a variety of oxygen sources.

During their visit, their research will be supported by Prof. Andreas Tiehm, Dr. Lara Stelmaszyk and M.Sc. Steffen Hertle.



Visiting the environmental technology lab at TZW. From left to right: Zhuanxia Zhang, Andreas Tiehm, Xiaojun Zhang, Zhengtao Li and Steffen Hertle (standing).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°965945.

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 continues to evaluate the effectiveness of the ENB technology on a pilot project in Spain. During the February site visit, one of the main activities was the injection of substrate for the second phase of remediation - bioremediation. An important upgrade of the direct current (DC) system was also carried out, where a new developed unit was installed. Further details are given below:

Substrate injection

Injection of 4 tonnes of glycerol-based substrate from three intermediate bulk containers was performed. The substrate was uniformly injected, using the developed dosing unit, into a total of 12 wells in two phases (see photos below).

Glycerol-based substrate (left) and dosing unit (right).

During the injection process, half of the substrate (125 L) was first injected into each borehole and diluted to a concentration of 50 g/L. In the second phase, the same volume (125 L) of substrate was then injected in undiluted form. This procedure was chosen to spread the substrate over a wide area around the borehole in the first phase. The second phase of injection was then used to deposit the substrate so that over time the substrate would be slowly distributed by the flow of water into the surroundings groundwater.

Installing a DC system upgrade

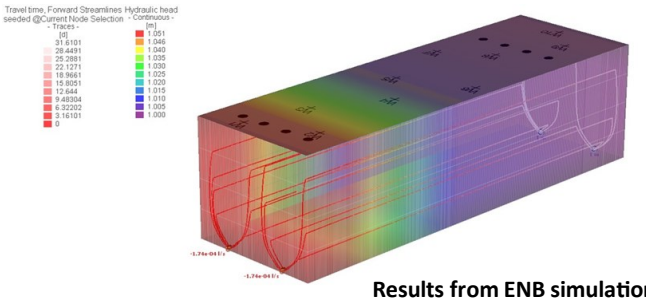
PWT and TUL have designed and manufactured a new module for the Direct Current (DC) system. This unit (see photo below) was installed and made operational at the pilot site during February.

Upgraded module for the DC system.

This upgrade has made it possible to either switch off the power electrodes completely or change their polarity (anode - cathode). The upper parts include a programmable logic controller and a module for measurement and GSM*. The middle section is dedicated to the switching relays that control the wiring of the power electrodes. With this upgrade, it will be possible to better influence the pH in the application zone to be in a range suitable (6-8) for the bacteria used in the bioremediation stage.

Numerical analysis of ENB experiments at VEGAS

In April, BOSS carried out a steady-state flow simulation to represent the ENB laboratory experiment at the USTUTT VEGAS facility, numerically and visualize the streamlines from the two inlets with their corresponding travel times. Keeping in consideration the main uncertainty in the experiments being the hydraulic conductivity of the reactive zone, the current results show a good agreement between observed and simulated travel time of up to 31 days.



Results from ENB simulation.

Chinese enhanced in situ bioremediation field study

ISSAS is conducting a field study in Zhangjiagang City, Jiangsu Province, China. The study area is approximately 150 m^2 and the main contaminants of concern are chlorinated volatile organic compounds and per- and polyfluoroalkyl substances. The demonstration site consists of three field studies to test emulsified vegetable oil-enhanced bioremediation, nanomaterials remediation, and nanomaterials coupled with bioremediation, respectively. Carboxymethyl cellulose nano-scale zero valent iron is the chosen nanomaterial. There are 26 groundwater monitoring wells and 10 injection wells in the demonstration area. Results will be reported when available.

Enhanced Phytoremediation (EPR)

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

Work progress

Field experiments applying EPR to soil contaminated with wood impregnation chemicals in Limmared, Sweden are ongoing. Groundwater samples are being collected that are analysed for PAH, oxy-PAH, metals, arsenic speciation and microbial community structure.

*** a Global System for Mobile Communication is a module used to establish communication between a mobile device or a computing machine and a GSM or GPRS system.**

Update on EiCLaR Technologies

Bioelectrochemical Remediation (BER)

CNRS, DVGW, ZJU 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

Large-scale Microbial Fuel Cells experiment

In February and March, a large-scale experiment (L/W/H = 6/1/1 m) was set up at the USTUTT VEGAS facility to investigate the technology of Microbial Fuel Cells (MFCs) for the degradation of petroleum hydrocarbons at ideally controlled boundary conditions. For the set-up, insights from small- and medium-scale experiments were optimized. Results from this experiment will provide valuable information regarding the scalability and optimization of the technology for field applications.

Hydraulic set up (left) and top view of the MFC (right).

UK pilot test

In May, CNRS carried out the first pilot test of the BER technology during the project. The site is located on a former gas station in the United Kingdom and is polluted with hydrocarbons. The technology was strategically placed on 5 monitoring wells and the performance results are expected after the Summer 2024.

Installing BER technology.

Chinese laboratory experiments and pilot test

ZJU continues to investigate reductive dechlorination in bioelectrochemical systems by employing different types of conductive materials and also the effects of geochemical conditions (e.g., co-existing ions) on electrokinetic enhanced bioremediation and microbial response.

A pilot-scale electrokinetic enhanced bioremediation has been established to treat a site contaminated with organochlorine compounds and chromium.

Monitored Bioaugmentation (MBR)

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

Work progress

Scale up of MBR culture

DVGW has started scaling-up the cultivation of the aerobic TCE degrading organisms. This is in preparation to further scale the bioaugmentation approach from successfully performed technical scale to a first pilot field site.

Scale-up cultivation of the culture (~300 L).

Culture blend investigation

In a series of experiments, DVGW demonstrated the inhibiting effects of chloroethenes that are not the primary substrate for different aerobic metabolic chloroethene-degrading organisms. In order to enhance the aerobic metabolic chloroethene degradation, a blend of different cultures resulted in a new mixed culture, now capable of simultaneous degradation of cDCE and TCE in aerobic metabolic processes.

Determining the soil oxygen demand of the NAM site soil

In anticipation of a potential field scale pilot test for the MBR technology at the NAM* site in Belgium provided by SPAQUE, the oxygen demand of the site soil has been determined in column experiments at DVGW.

Laboratory setup to determine the soil oxygen demand of the field site.

By introducing oxygen into the aquifer, the reduced soil will be oxidized and therefore consume a part of the oxygen provided. This leads to a direct competition for oxygen of the soil itself and the aerobic biodegradation of the chloroethenes, which will be facilitated through bioaugmenting the site with a bacteria culture capable of aerobic metabolic TCE degradation. The suitability assessment of the site for the application of the bioaugmentation approach has been done in laboratory batch experiments during the early phase of the project.

The determination of the soil oxygen demand will provide information that will allow the project partners to adjust the oxygen-dosage to facilitate both biotic and abiotic processes without oxygen-limitation.

*** Nouveaux Ateliers Mécaniques**

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.

Nicola's next interview was with two project partners who are working together on the same work package - Simon Kleinknecht and Petr Kvapil.

Simon is the technical director at the research facility for subsurface remediation, also known as VEGAS and is based at USTUTT, Germany and Petr is the managing director of PWT and is based in Prague, Czech Republic.

So first we're going to hear from Simon:

I was born in southern Germany and first came to Stuttgart for my education. I'm an environmental engineer by heart and Stuttgart was one of the first universities in Germany where you could study environmental engineering. I studied all sorts of water topics, from surface water irrigation, groundwater transport in porous media and eventually remediation. I went on to do my Masters at VEGAS about steam vapour injection as a remediation technology and then I continued by doing a PhD at VEGAS on how gaseous contaminants migrate through the variably saturated zone and how they might pose a risk to groundwater.

Afterward I got my PhD in 2016, I went away from academia and went into industry to try something completely different - software engineering. I learned a lot of programming skills and how industry works, and how big companies lead their teams. This has proven useful as last year I came back to VEGAS as a technical director, which has brought me back into academia and I'm happy to be back in research now.

Nicola from CL:AIRE interviewing Petr from PWT (L) and Simon from USTUTT (R).

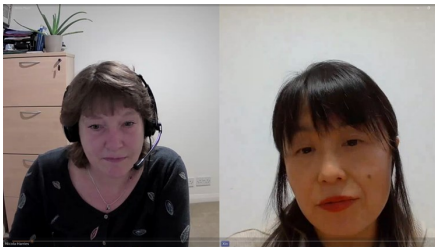
And now Petr's story:

Although I was born in Prague, I didn't live in Prague for a long time until I returned to study hydrogeology. Before I returned to Prague, I spent one year in Russia, where I started my studies in St Petersburg, in geology and mining. After political changes in my country, I went back to Charles University in Prague where I did my Masters before moving to France to do my PhD in environmental chemistry.

After my PhD I came back to the Czech Republic and joined an environmental company, Aquatest as a modeller. Here my main tasks were groundwater modelling, contaminant transport and for maybe 30% of my time remediation project management. It was this remediation element that became my focus and after a couple of years, I started to do research and development because there were a lot of new methods invented. We started to operate with nanoparticles and were successful in getting a grant for the development of new nanoparticles. These iron nanoparticles are currently widely used in the field of remediation and then of course we continued with the research and development.

I became a director of the Division of Research and Development and then I entered the Board of the company. It was here that I started thinking about changing the commercial environment, so I got in touch with the managers of Photon Energy Group and we agreed that it would be interesting for us to incorporate a new water-oriented company – Photon Water. So this was my next career step and I became a Managing Director of this company and our focus is on water, remediation and water treatment.

Nicola's next interview was with Professor Xin Song, the Chinese coordinator for the EiCLaR project and also a work package leader on nanomaterials coupled with bioremediation.



Nicola from CL:AIRE interviewing Xin from ISSAS.

I'm currently a professor with ISSAS, which is in Nanjing, China. Nanjing is a city which is about one and a half hours train ride from Shanghai.

I was born in China and my background is as an environmental scientist and engineer. I got my college degree and Masters in China, then I moved to America where I got my PhD from the University of Maryland, College Park. It was here during my PhD that I first got training in bioremediation, of naphthalene in particular.

I then moved into industry and worked for the consulting firm, Arcadis, where I received further training on soil and groundwater remediation and in particular in hydrogeology. numerical modelling and conceptual site model development. I think this has played a major role for my current research. I did also receive some training for *in situ* bioremediation which has been very useful for the EiCLaR project. After I worked for Arcadis for about 8 years, then, back in 2013, I relocated to China, and joined ISSAS. Here I formed a research programme, and right now in my group we have about 35 people. What we have been working on is soil and groundwater remediation for contaminants such as the chlorinated solvents, PAHs, chromium VI and the emerging contaminants PFAS. We have been working on technology development including *in situ* bioremediation, thermal treatment and permeable reactive walls, considering the occurrence, fate and transport and remediation of these contaminants in soil and groundwater.

Development of a Decision Support Tool

BOSS and R3 have been developing a web-based Decision Support Tool (DST) providing site-specific ranking and output, giving guidance to remediation companies, administrative, or site owners. The developed DST is based on the Operating Windows collating all relevant information of each technology required for a successful application. The DST employs a fuzzy-logic algorithm to interpret the information stored in the Operating Window. It can be easily extended to include other technologies. A user-friendly graphical interface (front end) has been programmed to allow users to manipulate site-specific input data, gain further information from the knowledge base, and access supporting services to complete the user journey. A business plan has been developed to commercialize the DST and complete the decision support guidance. More details will be available later this year.

Screenshot of the DST parameter input form.

Keeping Informed

The best place to keep informed about EiCLaR's progress, activities and events is to visit our 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.

Alternatively, you can get updates via LinkedIn or WeChat (available in China) or by contacting Timothy M. Vogel at CNRS via email: vogel@univ-lyon1.fr

The next EiCLaR Newsletter will be published in Autumn 2024 and will provide further updates on the EiCLaR technologies and the wider project work. We will also be participating at RemTech Europe 2024 and hope to see many of you there!

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