ISSUE #7 | FEBRUARY 2025

Phy2Climate

NEWSLETTER PHY2CLIMATE PROJECT

Clean biofuel production and phytoremediation solutions from contaminated lands worldwide

We are pleased to share the seventh issue of Phy2Climate newsletter, keeping you up to date with all the latest news and developments from the project. Phy2Climate is a project funded by Horizon 2020 EU's Research and Innovation programme. The overall objective of the Phy2Climate project is to build the bridge between the phytoremediation of contaminated sites with the production of clean drop-in biofuels and bio-coke.

CONTENTS

Pilot site visit and Open Day in Argentina

Argentinian partners of INTA, in collaboration with the project consortium, organised the Argentinian pilot site visit for partners, collaborators, researchers and officials and technicians from the Ministry of Mining of the Province of San Juan, and the second Phy2Climate project Open Day in November 2024.

The Argentinian pilot site is located in La Planta, Caucete Department, southeastern San Juan Province. A relevant mining zone until the early 1970's is located in La Planta (31°10'24,38" S, 67°52'57,26" W) and Marayes (31°10'55,83" S, 67°24'38,04" W) in the province of San Juan, Argentina. Mining activity in the province of San Juan dates back to the early 1800's and gold was extracted using water from the Papagayos River in La Planta, which is located 6 km from Los Marayes mines. Regarding geomorphology, the area is located in an extensive alluvial plain of the Bermejo river. Primary and secondary streams are often dry and only have water during certain seasons. The vegetation is uniform both in its appearance and in its diversity of species, changing according to the topography.

INTA carried out a phytoremediation strategy in this mining zone in La Planta. The study area is in an arid environment which corresponds to the "Monte" phytogeographic province. It has a dry and warm climate with mainly summer (December-March) rainfall of a torrential nature, ranging between 80 and 200 mm per year. Temperatures are very high and reach an absolute maximum of 46 °C. These are extremely arid environmental conditions.

The Argentinian pilot site is in La Planta town, Department of Caucete, San Juan Province.
Credit: ETA Florence.

Mining impacts the environment and causes losses in great soil surfaces. Consequently, high concentrations of metal(loid)s in the remaining waste cause soil pollution inducing adverse effects in exposed organisms. Metal(loid)s are not biodegradable and can accumulate in different levels of the food chain, threatening food safety and human health. Remediation strategies prevent pollution from spreading and avoid losses in ecosystem functions. In particular, phytoremediation is considered a highly profitable and socially accepted alternative. Plants growing in contaminated environments are the most valued candidates as phytoremediation species. However, it is necessary to know plant response during its different developing stages, such as physiological and biochemical mechanisms underlying metal(loid) exposure.
Plants growing in arid environments face extreme environmental factors like temperature, salinity, and water stress. Native trees and shrubs were identified by INTA experts in an arid environment impacted by an abandoned gold mine in La Planta, San Juan, Argentina. Plant species such as Larrea *cuneifolia*, *Prosopis flexuosa*, *Plectocarpa tetracantha and Bulnesia retama* can tolerate and bioaccumulate high concentrations of As, Cu, Zn and Cd. Although authors proposed these species for phytoremediation purposes, there is a gap in the knowledge about their response in earlier stages of development.
Two sampling sites were selected: a site with abandoned mining waste and a reference site used as a control, which were previously characterized.
In La Planta, indigenous and poor settlers who inhabit the contaminated area raise free-roaming goats, so a simple perimeter fence was installed to prevent herbivory and protect seedlings.
Along with cultivating highly heavy metal-tolerant but slow-growing plants with low biomass yield per hectare, a faster-growing plant capable of absorbing heavy metals was sought, leading to the selection of quinoa.

Biomass from the first and second quinoa crop cycle was manually harvested in January and July 2023, then dried, crushed and pelletised for the thermo-chemical conversion process.

The **Phy2Climate Open Day** was organized by INTA, one of the project partners, as study tour of the *Anchipurac Environmental Training Centre* in San Juan province, on Thursday 14 November 2024, afternoon.
Project partners presented the main processes and displayed various materials produced by the project, including biomass pellets, marine biofuel, biodiesel, and biogas. In addition, local environmental initiatives and projects were showcased by educational institutions at every level, from kindergarten to tertiary institutes and universities. The San Juan experimental station from INTA showcased regional products made by local farmers and INTA staff, including olive oil, wine, and nuts.

Project partners at the Argentinian pilot site in La Planta town, Department of Caucete, San Juan Province.
Credit: ETA Florence

Phy2Climate presentation at the Open Day: Partners showcased various project materials including biomass pellets and biofuels.
Credit: ETA Florence.

Phy2Climate

Project team and San Juan high school students at the Open Day.
Credit: ETA Florence.

In addition, two Phy2Climate workshops were organised in the same week of the pilot site visit and Open Day. The first workshop was titled "Phytoremediation of contaminated soils and biofuel production" (Castelar, Buenos Aires) and the second one was titled "Green technologies: phytoremediation of soils with environmental liabilities and biofuel production" (Anchipurac Environmental Training Centre, San Juan province).
The audience at the event of Buenos Aires consisted of different stakeholders, from academia (researchers, authorities of Research Centres and Universities), government (decision makers, public policy, agriculture, waste management, and environmental monitoring), companies (different sectors represented such as petrol and gas, biogas, consulting, equipment providers for laboratories, farming, and environmental management), and education (professors and students).

Project workshop "Phytoremediation of contaminated soils and biofuel production" in Castelar, Buenos Aires, Argentina.
Credit: ETA Florence.

Project partners and local stakeholders in Buenos Aires, Argentina.
Credit: ETA Florence.

Also, companies such as mining, farming, photovoltaic/solar energy and environmental management, and teachers and students from different levels of the education system (such as universities, primary and secondary schools) attended the second workshop in San Juan province.

Project workshop "Green technologies: phytoremediation of soils with environmental liabilities and biofuel production" at the Anchipurac Environmental Training Centre in San Juan province, Argentina. Credit: ETA Florence

For further information:

See video interviews Intro to the **Argentinian pilot site** Click here

Video of Phy2Climate Event & Open Day in Argentina Click here

and check these scientifc articles:

"Phytoextraction of Cu, Cd, Zn and As in four shrubs and trees growing on soil contaminated with mining waste", Chemosphere, Elsevier, August 2022, Click here

"Strategies of physiological, morpho-anatomical and biochemical adaptation in seedlings of native species exposed to mining waste", Ecotoxicology and Environmental Safety, Elsevier, January 2025, Click here

the project webpage **Resources** Click here

Scientific Paper "Application of herbaceous plant mixtures for remediation of TPH-contaminated soil"

Rubežius, M., Kidikas, Ž., Kasiulienė, A., Kemešytė, V., & Stukonis, V. (2024). Application of herbaceous plant mixtures for remediation of TPH-contaminated soil. International Journal of Phytoremediation, 1–13. link

The scientific paper was authored by experts of the Biovala team, a partner in the Phy2Climate project, in collaboration with Vytautas Magnus University and the Lithuanian Research Centre for Agriculture and Forestry.

Soil contamination by petroleum hydrocarbons (TPH = total petroleum hydrocarbons) is one of the most widespread contaminations worldwide and is caused by the ever-increasing demand for petroleum-based energy and the extensive exploitation of petroleum compounds. TPH affect the chemical, physical and biological balance of the soil and can enter food chains. Therefore, remediation of contaminated soils is essential to ensure better environmental conditions and public health. Traditional physical and chemical methods for cleaning soil are efficient at removing pollutants and work quickly but are expensive, require substantial energy and labour, alter soil properties, and may lead to secondary pollution. An alternative to physical and chemical cleaning methods is biological cleaning methods, including phytoremediation, which is recommended as an effective, cost-efficient, and environmentally friendly technology for treating contaminated soil.

Rhizodegradation is the primary method for phytoremediation for petroleum-contaminated soil, emphasizing the stimulation of organic-degrading microorganisms within the plant rhizosphere. In this region, plant roots create a favourable microenvironment and serve as a carbon source for hydrocarbon-degrading microorganisms. Whether introduced or native, these microorganisms lower soil toxicity and promote plant growth and metabolism by removing organic contaminants. They also support root development and help reduce the production of stress hormones.

Improving soil texture is often necessary for successful plant growth in contaminated sites, as these soils are typically of poor quality, compacted, and have low hydraulic conductivity, dissolved oxygen and organic matter. Contaminated soils often lack essential nutrients, making organic and mineral supplements are necessary to ensure optimal plant growth. Like naturally occurring microorganisms in rhizospheres, introduced microorganisms enhance the mobility, bioavailability, and uptake of both organic and inorganic contaminants. Therefore, complex solutions for plant selection, restoration of soil vitality and enrichment with nutrients are the key to effective rhizodegradation. Due to the need to expand the existing methods for remediating TPH-contaminated soil through biotechnology further advancement in this field of scientific research is essential.

Contaminated soil was collected from the southwest of Šiauliai city, Lithuania. In the Soviet period, the site was exploited as an oil base. After Lithuania reclaimed independence in 1990, the site was abandoned, and the last on-surface oil tanks were removed in 2009. During the removal of oil tanks, substantial amounts of oil were spilled throughout the territory.

To assess the phytoremediation potential, contaminated and clean soil samples prior to the pot experiment and after the harvest of plants were evaluated.

Sampling phase at the Lithuanian pilot site of Phy2Climate project.
Credit: BIOVALA.

The conducted studies revealed that the selected herbaceous plant species and their mixtures can be successfully grown in contaminated soil at a contamination level of 6,817 mg/kg TPH dry matter (DM) according to the selected cultivation strategy. By integrating biotechnology and agronomic solutions, mixtures of cultivated herbaceous plants can achieve equal or even higher biomass yields, while selected herbaceous plants exhibits no physiological changes when growing in contaminated soil. Undoubtedly, the use of organic, mineral, and biological additives yielded positive results in these studies. Some of the selected plants including red and white clovers, honey clover meadow foxtail and common bent, failed to germinate and should be either replaced or removed from the mixtures.

After two years of remediation, the resulting plant mixtures showed excellent TPH removal efficiency (90%). Additionally, the lighter fractions of petroleum hydrocarbons break down more easily. Heavier fractions (diesel, oil, and residue), which prevailed in the contaminated soil, degraded less, but in all cases, a decrease in the concentration of all fractions was observed. Although two growing seasons were insufficient to reduce the TPH concentration below the maximum permissible levels in these studies, the results demonstrates significant potential for successful application in field trials.

For more details:

Please refer to the content of this **article** Click here

Project **deliverables** Click here

Scientific Paper: "Phy2Climate: Life Cycle Assessment of phytoremediation combined with biofuel production"

Simla, Tomasz Grzegorz and Korus, Agnieszka and Petela, Karolina and Stanek, Wojciech and Ortner, Markus and Szlęk, Andrzej, Phy2climate: Life Cycle Assessment of Phytoremediation Combined with Biofuel Production. Available at SSRN: link or link

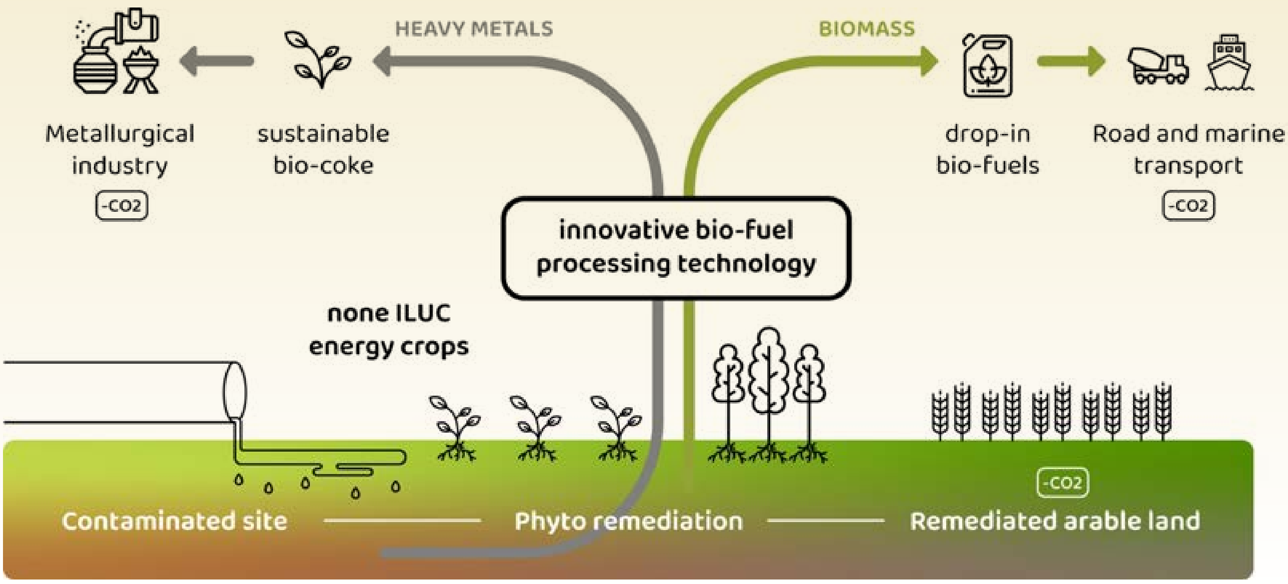
This paper was presented at CPOTE2024 conference, the 8th International Conference on Contemporary Problems of Thermal Engineering which brought together scientists involved in energy, exergy and ecological analysis. The main theme of CPOTE2024 was Towards sustainable & decarbonized energy system. CPOTE2024 was held in Gliwice, Poland between 23-26 September 2024.

The manuscript covers preliminary results of the Life Cycle Assessment study for the Phy2Climate processes and technology.

Authors are experts of the Department of Thermal Technology, Silesian University of Technology, Gliwice, Poland, project partner of Phy2Climate.

This work presents the results of the first iteration of Life Cycle Assessment of phytoremediation and biofuel production. Primary inventory data have been collected from four pilot phytoremediation sites and from the biorefinery and supplemented with secondary data based on literature review and own mathematical calculations. The data have been then fed into a LCA model of pilot sites and biorefinery prepared in LCA for Experts software. Environmental impacts have been calculated using Environmental Footprint 3.1 methodology. The results confirm positive impact of phytoremediation on the ecotoxicity and human toxicity impact categories, as well as show the potential of Phy2Climate approach in the field of reduction of emissions of greenhouse gases.

Life Cycle Assessment has been applied for some phytoremediation projects globally and the results of these studies have been reported in the literature. However, the number of papers on this topic is still scarce, as highlighted in review articles. The papers deal with removal of a variety of contaminants from the soil, including heavy metals, hydrocarbons and overdosed fertilizers. Majority of the reviewed LCA studies have a comparative character, with the goal of comparing the environmental impacts of phytoremediation with those of alternative remediation options, usually excavation and-refill. There are also examples of LCAs comparing various crops that can be used for phytoremediation and non-comparative LCAs, such as which focuses on resilience of phytoremediation to the rise of sea level. Some studies are constricted to evaluation of carbon footprint (global warming potential) of phytoremediation instead of full environmental assessment.



The Phy2Climate concept: overview of the project.
Credit: Phy2Climate project.

The obtained results of the Life cycle impact assessment (LCIA) for phytoremediation show that consumption of fuel is the greatest contributor to almost all impact categories. Only the use of fertilizers has a comparable impact in some 583 categories (for example Ozone depletion). Removal of contaminants from the soil has a beneficial impact on categories Ecotoxicity and Human toxicity. These beneficial impacts generally outweigh the adverse impacts caused by other groups of activities, resulting in an overall negative value of these environmental impact indicators. It must be stressed that the presented results are based on inventory data from the first year of phytoremediation. It is expected that in the subsequent years, the rate of contaminants removal will decrease, which will reduce the positive impacts in Ecotoxicity and Human toxicity categories. However, at the same time, the biomass yield may increase, potentially improving the environmental impacts of the entire process. Additionally, for scaled up phytoremediation sites, the specific fuel consumption for agricultural activities is expected to be lower.

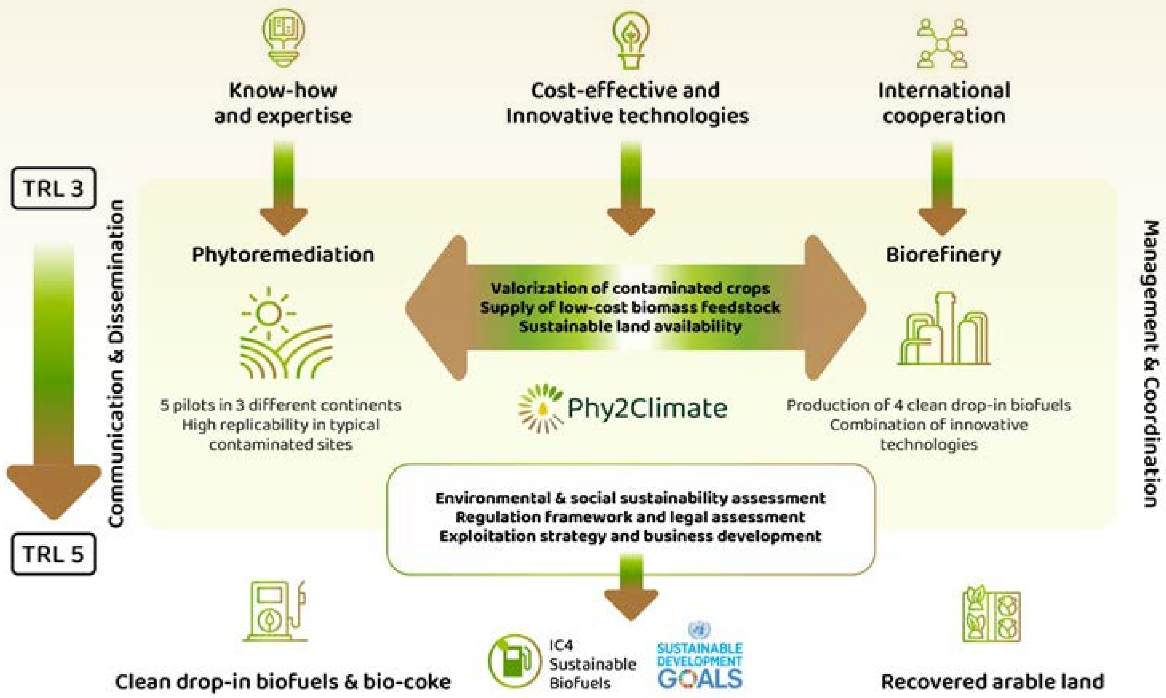
Please refer to this **article** Click here

Project deliverables Click here

Business-Models for Phytoremedation and Biofuel Production

The economic evaluation of the Phy2Climate process has been an integral part of the project and exhaustive data collection regarding the feasibility of combining phytoremediation and biofuel production was driven by project partners involved in the assigned work package. Recently another key deliverable summarized the findings regarding potential business model. Although the deliverable and the detailed outcomes are confidential some insights can be shared in this newsletter.

In order to identify possible business models a scenario approach was chosen. Inspired by the pilot sites in this project four approaches were described. Four scenarios in different geographical regions, climatic conditions, contaminants, dimensions and processing capacities should help to understand the main critical factors and interdependencies.



The overall approach of Phy2Climate.
Credit: Phy2Climate project.

In brief the analysis shows that the Phy2Climate approach is an interesting approach is economically more advantageous than conventional interventions such as containment or dig and dump. The disadvantage is that phytoremediation requires more time. It is interesting to observe that transportation of biomass or products does not have a significant. However, the cost for staff managing the whole process, particularly the biomass conversion process, is a big impact factor. Thus, the more contaminated sites need to be treated the less advantageous the process becomes. An increase of biomass conversion capacity would become beneficial mostly if staff cost can be decreased through this intervention. Lastly, it can be shared that at the moment the products from the TCR (Thermo-Catalytic-Reforming) conversion do not contribute enough to reach a positive result. Despite these observations, there are several arguments and specific configurations that could make Phy2Climate an economically feasible approach with a positive impact on environment and society.
Since the business models have now been analyzed and described, the partners involved in this process now focus on identifying a potential roadmap for upscaling and exploitation. Two specific situations are being developed and discussed with partners. Potential piloting approaches are calculated, and necessary steps outlined.

DID YOU KNOW THAT...

there is a significant area of land on our planet which is contaminated and therefore unusable for any purpose?

2.5 million
contaminated sites in Europe

9 million
hectares of contaminated sites in USA

13-20 million
hectares of contaminated sites in China

ARABLE LAND

is a finite resource.

It is used for:

FEED 71%
FOOD 18%
BIOFUELS 4%

WHAT IF...

the land was decontaminated and biofuels were produced without Land Use Change in one technology chain?

Phy2Climate

PHY2CLIMATE

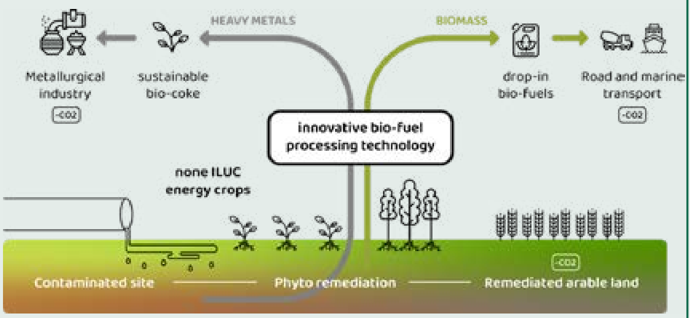
Clean **biofuel** production and **phytoremediation** solutions from contaminated lands worldwide

PHYTOREMEDIATION

Use of plants and their associated microbes to stabilize, degrade, volatilize and extract soil pollutants. The plants become biomass which can be pelletized.

BIOFUEL PRODUCTION

The biomass is converted then in a biorefinery into clean drop-in biofuels. Bio-coke for metallurgical industry is also produced. The technology applied is called Thermo-catalytic reforming (TCR).



LEARN MORE!

CLICK HERE

to watch
the Phy2Climate video -
the project in a nutshell

www.phy2climate.eu

info@phy2climate.eu

Phy2Climate

@phy2climate

Phy2Climate

Source: SUT, Silesian University of Technology

Phy2Climate

info@phy2climate.eu

Phy2Climate Project

Phy2Climate Project

www.phy2climate.eu

The project consortium has put together 16 partners from 9 countries with long-term expertise in soil remediation, phytoremediation, biofuel technologies and energy processes, environmental and social sustainability, legislative analysis, communication and dissemination as well as business development for innovative technologies.

Phy2Climate is a H2020 project with title "A global approach for recovery of arable land through improved phytoremediation coupled with advanced liquid biofuel production and climate friendly copper smelting process

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 101006912.