(Projects funded under the Call 2014 onwards must use this format)

LIFE Project Number

LIFE18 ENV/CZ/000374 LIFEPOPWAT

Final Report

Covering the project activities from 01/01/2020[1] to 31/12/2023

Reporting Date[2]

30/03/2024

LIFE PROJECT NAME or Acronym

Innovative technology based on constructed wetlands for treatment of pesticide contaminated waters

LIFEPOPWAT

Data Project

Project location:	Czech Republic, Poland, France, Denmark
Project start date:	01/01/2020
Project end date:	31/12/2023 **Extension date:** -
Total budget:	3 141 515 €
EU contribution:	1 727 833 €
(%) of eligible costs:	55%

Data Beneficiary

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[1] Project start date
[2] Include the reporting date as foreseen in part C2 of Annex II of the Grant Agreement

This table comprises an essential part of the report and should be filledin before submission

Please note that the evaluation of your report may only commence if the package complies with all the elements in this receivability check. The evaluation will be stopped if any obligatory elements are missing.

Package completeness and correctness check	
Obligatory elements	**✓ or N/A**
Technical report	
The correct latest template for the type of project (e.g. traditional) has been followed and all sections have been filled in, in English *In electronic version only*	✓
Index of deliverables with short description annexed, in English *In electronic version only*	✓
<u>Final report</u>: Deliverables not already submitted with the MTR annexed including the Layman's report and after-LIFE plan Deliverables in language(s) other than English include a summary in English *In electronic version only*	✓
Financial report	
The reporting period in the financial report (consolidated financial statement **and** financial statement of each Individual Beneficiary) is the same as in the technical report with the exception of any terminated beneficiary for which the end period should be the date of the termination.	✓
Consolidated Financial Statement with all 5 forms duly filled in and signed and dated *Electronically Q-signed or if paper submission signed and dated originals* and in electronic version (pdfs of signed sheets + full Excel file)*	✓
Financial Statement(s) of the Coordinating Beneficiary, of each Associated Beneficiary and of each affiliate (if involved), with all forms duly filled in (signed and dated). The Financial Statement(s) of Beneficiaries with affiliate(s) include the total cost of each affiliate in 1 line per cost category. *In electronic version (pdfs of signed sheets + full Excel files)) + in the case of the Final report the overall summary forms of each beneficiary electronically Q-signed or if paper submission, signed and dated originals**	✓
Amounts, names and other data (e.g. bank account) are correct and consistent with the Grant Agreement / across the different forms (e.g. figures from the individual statements are the same as those reported in the consolidated statement)	✓
Mid-term report (for all projects except IPs): the threshold for the second pre-financing payment has been reached	✓
Beneficiary's certificate for Durable Goods included (if required, i.e. beneficiaries claiming 100% cost for durable goods) *Electronically Q-signed or if paper submission signed and dated originals* and in electronic version (pdfs of signed sheets)*	N/A
Certificate on financial statements (if required, i.e. for beneficiaries with EU contribution ≥750,000 € in the budget) *Electronically Q-signed or if paper submission signed original and in electronic version (pdf)*	N/A
Other checks	
Additional information / clarifications and supporting documents requested in previous letters from the Agency (unless already submitted or not yet due) *In electronic version only*	✓
This table, page 2 of the Mid-term / Final report, is completed - each tick box is filled in *In electronic version only*	✓

**signature by a legal or statutory representative of the beneficiary / affiliate concerned*

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2. List of key-words and abbreviations

Key word:

Wetland, Wetland+®, HCH, lindane, water remediation, passive remediation systems, POPs

List of abbreviations:

AB – Advisory Board

C2M – Close to market

ClB – chlorobenzenes

ClPh – chlorophenols

CZ – the Czech Republic

DIA – DIAMO, state enterprise

EB – Executive Board

GIG – The Central Mining Institute

HCH – isomers of hexachlorocyclohexane (α, β, γ, δ, ε)

JAW – City of Jaworzno

LCA – Life Cycle Assessment

LifePopWat – project ackronym

MM – number of man-months

Modul A – sedimentation of Fe-oxides

Module B – PRB with Fe-chips

Modele C – biodegradation/biosorption

Module D – constructed wetland

NFOSiGW - National Fund for Environmental Protection and Water Management

ORP – oxidation reduction potential

OCP – organochlorinated pesticides (DDT, heptachlor, endosulfan, …)

P1 – pilot prototype at Hajek, CZ

P2 – pilot prototype at Jaworzno, PL

PL – Poland

PMC – Project Management Committee

POPs – Persistent Organic Pollutants

PWT – Photon Water Technology

SER – SERPOL

TUL – Technical University of Liberec

URA - Water Agency of Basque Country

qPCR – polymerase chain reaction

VOC – volatile organic compounds

Wetland+® - registered remediation technology

WWTP – wastewater treatment plant

3. Executive Summary

The main objective of the LifePopWat project was to mitigate risks to water from hexachlorocyclohexane (HCH) contaminated sites using the recently developed Wetland+® technology and to achieve how this technology might be replicated across the EU and globally. Specific objectives were a) to install a large-scale pilot prototype “P1” at Hajek (CZ) to provide proof-of-concept at a commercially relevant scale and an exemplar to support replication; b) to set a field pilot deployment prototype “P2” at Jaworzno (PL), which has a different application context, in terms of hydrogeological conditions, microbial communities, and local resources such as sorbent materials, c) to establish a specific replication pathway for the technology to be applied at other sites, d) to test an innovation in the performance of green monitoring, sustainability assessment and analysis e) to develop process control strategies for remote locations by use of renewable energy and resources; f) to disseminate the project through the involvement of and communication with various audiences and interest groups on a European and global scale.

The Wetland+® process combines a sequence of *in situ* treatments followed by a polishing stage in an engineered wetland. The treatment stages are:

In the first half of the project period, the main output was the construction of the pilot prototype “P1” and the setting up of monitoring its effectiveness by performance and environmental monitoring. The build-out was rapid because all the necessary permits for the system were in place before the start of the project. The slight delay in construction was due to the necessity of changes in the original design because of new facts. Owing to the bearing capacity of the bedrock, more earthwork was needed than planned. Tanks were not made of precast concrete but were cast in concrete as monoliths, which was better suited for site construction conditions. P1 commissioning took place as time-tabled from September 2021, including integrity testing and a trial operation period. Some minor construction also took place over this period, such as the connection of all mine heap drains into one inspection shaft, installation of roofing on the pools of module B, or installation of automatic flow measurements and a data-logging system, were performed later on in 2021 (some of them outside of the planned project activity and financed from external sources).

During the second half of the project period, the system was fine-tuned to increase its efficiency. Teething problems were expected during this first full-scale implementation and some difficulties were encountered. These were successfully managed and the system operation was optimised. The main problems encountered were mainly with reducing the reactivity of the Fe fillings. Repeated mixing of the Fe fillings by an excavator disrupted the preferential water pathways in the B modules.

The second problem was the extreme flow rates, where the whole system is designed for a maximum flow rate of 3 l/s, but the flow repeatedly increases to 5 l/s in the spring months. The last major problem was the insufficient residence time of the water in module A to enable the sedimentation of Fe-oxyhydroxides. These fine sediments entered module B and reduced their permeability. It was, therefore, decided to disconnect module A from the system, which leaves the water entering module B anoxic. During this period, there has also been wetland plant growth in module D, increasing its effectiveness. This trend will continue.

More significant difficulties were encountered in Jaworzno's “P2” installation. Within the preparatory action, the project team designed the system at the site, its location in the landscape, its size, and the volume of water flowing. The construction works started in August 2021, but from November 2021, a significant slowdown was reported. An access road, electrical installations, two wells, an expansion tank and two containers, and two wetland ponds were completed, along with the planting of vegetation. Unfortunately, the contractors did not deliver the remaining construction work (including installing the remaining six containers). Their contract had to be terminated, and a new tender was prepared. The new construction company started in mid-November 2022, and the work was finished on the 27th 12. 2022. The delay did not significantly affect the project results even though the P2 system was commissioned about one year after the plan. The system's primary objectives were to see the system adaptation to another type of environment and composition of contaminated water, as well as the use of the solar power source for the system operation, which all was successfully tested in the remaining year of the project period.

Over the system testing period, 25 sampling campaigns were performed at the P1 site. System efficiency significantly depends on the flow. If the flowrate is below 3.0 l/s, the efficiency for HCH removal is over 84%. In the case of extremely high flow (up to 5 l/s), the efficiency dropped to 50% and 70% in the first and second years of performance, respectively. This efficiency increase is due to wetland plant growth. The system's overall efficiency will increase because the vegetation is also expected to increase in the coming years. Equally, 21 sampling campaigns were performed at the P2 site. The efficiency gradually increased, and from June to the end of July 2023, where the flow was reasonably low (1.0 to 2.5 l/min), a relatively high HCH removal efficiency of 83% was observed. The major problem was keeping the constant inlet HCH concentration because the source was mixed from two wells with variable concentrations. Monitoring has shown that the system is fully operational and achieving the expected results at both sites.

The environmental monitoring found decreasing concentrations of HCH and other substances near sites P1 and P2. Until August 2021, all analyses described the initial site contamination (baseline). Since August 2021, Hájek environmental matrices have been positively influenced by the operation of the completed P1 prototype that treats the effluent from the HCH waste dump. Most of the collected water, plant and animal samples showed either negligible HCH values or values gradually decreasing after P1 system commissioning. The increasing biodiversity and environmental purity of the outflow water recipient, Ostrovsky Creek and the following water system were proved by the number of diatom species (and Shannon diversity index).

Monitoring of socio-economic impacts confirmed that Wetland+® offers gains in socio-economic performance over conventional wastewater treatment plants (WWTP) or no action (*status quo*). The LCA analysis confirmed that the total environmental burden of Wetland+® is about an order magnitude lower than WWTP.

A Project Communication & Dissemination Plan was used for the whole project duration, including communication strategy, target audience, and tools like the project logo, graphic project identity, templates, and web pages. The most likely application for Wetland+® is for sites with inaccessible sources of contamination, not located, diffused, or otherwise hard to treat, and for a nature-based solution easily integrable in landscape and supporting biodiversity improvement. This passive treatment leads to reduced treatment costs, especially concerning OPEX, and Wetlands+® represents the only sustainable solution for closed sites without running economic activity or production. Replication and business planning have selected potential candidates for the replication. The most promising sites are Pais Basco/Jata landfill (Spain), Aragon /Sabinanigo (Spain) and Libis (Czech). Two other sites are considered – Galicia /Porrino (Aragon) and Westerelgen (Germany).

4. Introduction

Description of background, problems and objectives

This project focused on applying natural oxidation-reduction and adsorption processes in artificially constructed wetlands to treat water contaminated by hexachlorocyclohexane (HCH). HCH isomers (α, β, γ, δ, ε), as well as impurities from HCH production and transformation products such as chlorobenzenes (ClB) are a severe and persistent environmental problem at many sites around the world. In particular, α, β, and γ isomers are listed under the Stockholm Convention on Persistent Organic Pollutants (POPs) (EC Regulation No. 850/2004). As HCH bioaccumulates in freshwater food chains (fish, crustaceans) and enters the biomass of plants and broadleaf trees, the potential for cumulative chronic long-term harm to living organisms is high. Before their use was banned in 2007, HCH production across Europe led to at least 300 sites, including 40 mega sites, with total HCH waste exceeding 250 thousand tons (www.ihpa.info).

The project objective was to mitigate risks to HCH-containing water outflowing from contaminated sites using naturally-based technologies and how this can be replicated across the EU and globally. The Wetland+® technology introduced during the project is based on integrated reactive zones (oxidation/sedimentary tanks, permeable reactive reduction barriers, sorption units) with an aerobic wetland as the final treatment step. The project proposed to reduce the HCH (and chlorobenzenes) levels in flowing water significantly and permanently. Moreover, the project benchmarks were performance, ease of deployment, and sustainability against conventional approaches (WWTP or excavation). LIFEPOPWAT focused primarily on mega sites, representing the most intractable ongoing HCH problem. In contrast to source zone remediation, Wetland+® offers more robust, low maintenance, and sustainable treatment of outflowing contaminated water (leachate, drainage). Moreover, the approach is also down-scalable for smaller problematic sites.

Specific objectives were defined and fulfilled during the project implementation to reach the project objective. These are: (1) The proposed Wetland+® setup was tested as a large-scale pilot prototype at Hajek (P1, CZ). P1 aimed to exhibit system performance commercially relevantly and provide an exemplar to support replication. (2) The field pilot prototype on a smaller scale was built at Jaworzno (P1, PL). P2 aimed to exhibit the site-specific replication pathway of the technology for other sites, considering site differences such as contamination context, hydrogeological conditions, microbial communities, and local resources such as sorbent materials. Both implementations were based on applying the various modules of the Wetland+® technology, i.e., abiotic reduction, sorbent systems, biodegradation and wetland. (3) A specific project replication process has been established, and candidate sites have been actively canvassed to consider them for the feasibility study stage. A business model was prepared to service replication needs. (4) The green monitoring via the monitoring of HCH in tree biomass to reduce costs was verified. (5) Using renewable energy and process control strategies for remote locations were established. (6) Targeted communication and dissemination ensured that the results of this project reached different audiences and interest groups on an EU and global scale.

The Hajek site is near the Karlovy Vary spa in Western Bohemia (the Czech Republic). Uranium mining occurred here between 1965 and 1971, during which a tailings impoundment was created. Following the cessation of uranium mining, kaolin, basalt and later bentonite mining began in the foreground of the open pit. In 1966-1968, according to the decision of the state authorities, about 3-5 thousand tonnes of residual ballast isomers of HCH and ClB from the production of lindane (γ-HCH) from the Spolana chemical plant (Neratovice, Czech

Republic) were loaded into the spoil heap. Since the beginning of the century, the average content of HCH and ClB is about 100 µg/l and 600 µg/l, respectively, and the mass flux of approximately 25 g HCH and 150 g ClB per day. The contaminated drainage water flowed via the Ostrovsky brook to the Hajek preserve and the adjacent breeding ponds Horni Stit and Dolni Stit.

The contaminated site Rudna Góra is situated in the eastern part of Jaworzno and the Vistula (Wisła) river basin. Since 1921, the Organika-Azot S.A. Chemical plants have operated in the Wąwolnica river valley. The lindane production of consequently HCH waste generation has been performed predominantly from 1965 till 1982 in Jaworzno (production of technical HCH amounted to 4,000 tons/year and γ-HCH amounted to 300 tons/year). Many of these compounds were deposited at the Rudna Góra Central Waste Dump and surrounding areas for years. Unfortunately, this waste collection and the nearby areas where other POPs were also found do not have any protection against groundwater pollution.

The Wetland+® technology is based on multiple systems of different installations. The contaminated water from a source (landfill, waste disposal site, repository, etc.) flows into sedimentation tanks, where dissolved iron in inlet water is oxidised to iron oxides and precipitated. This first step can be neglected if the Fe content is low or the water is in the reductive state. In the case of P1, it was also excluded due to the very slow sedimentation of formed Fe oxides and the low removal. The first reactive step involves the creation of in-situ reductive zones using zero-valent iron (ZVI) in the form of chips, wires, or shavings, where HCH is pre-treated (chemically reduced and converted to ClB). The HCH and ClB outflowing mixture flows into a sorption/biodegradation unit. Sorption processes linked with applying low-cost materials, such as woodchips, in refillable cartridges ensure the sorption of the contaminants and subsequent biodegradation by microorganisms. The next step involves an aerobic bioremediation unit (wetland), where additional biodegradation occurs.

Expected longer-term results

The expected environmental benefits include a reduction of HCH and ClB below the prescribed environmental limits. Namely, at the larger P1 site (Hajek, CZ), the regulatory target concentration in the outflow water for total HCH isomers is less than 0.02 µg/l, which represents a 99% reduction in the current levels, and ClB concentrations below 1 µg/l. This means the annual treatment of 60,000 m^3 of water. These installations require no chemicals, no additional energy (except for water pumping to the system's inlet) and no human intervention (except for infrequent maintenance). In addition, the P1 wetland is expected to increase biodiversity at the site because a new waterbody is formed, and new species are planted there. This is important because the site is close to a Natura 2000 site. Similar effects were observed at the smaller P2 site but at different water compositions.

Besides the direct environmental benefits, the project has other administrative results. The first category is related to replicating the installation at different locations. Two key actions are supporting wider deployment of the technology to other sites - preparation of a Technology Guide to support future design and decision-making elsewhere and an action for Replication and Business Planning to provide a service to underpin replication. This action includes selecting candidate sites for the Replication Conveyor Belt, Service package for the clients of Wetland+® technology, Feasibility study and selection of potential candidates. An After-life plan covers all these activities. Besides the outputs for experts, there is also an output for the public in the form of Layman´s report, a video about the pilot sites, and a website with the project's main results. Moreover, the project results are being published in scientific papers and presented at international conferences for the scientific community.

5. Administrative part

The project was managed by the project manager (PM) and financial manager (FM, replaced during the first year due to maternity leave), who ensured the smooth implementation of project activities in the planned schedule. The PM was also responsible for communicating with the EC and ensuring the contractual basis. The FM performed all financial transfers to partners on time and prepared economic issues to be approved by the Project Management Committee (PMC).

The management bodies were PMC, responsible for the overall administrative and financial management; the Executive Board (EB), was responsible for the execution of activities in the framework of the planned Actions, and the Advisory Board (AB) was responsible for monitoring and supervising the implementation of the project. The smooth management process was ensured by communication among the PM bodies via e-mails, phone calls, and conference calls. Important project decisions were made at the regular semi-annual meetings (PMCs).

All the beneficiaries participated in the project as proposed with few tiny deviations due to COVID restrictions, problems during P2 building, or to ensure project outputs. Cooperation between the universities, representing research subjects, private enterprises, business partners, and authorities provided added value and was smooth during the whole period of the project. No significant deviations from the work plan were made, except for minor shifts in the schedule due to COVID-19 and technical upgrades within specific Actions (see 6. Technical part).

Communication with the Agency and the Monitoring Team was helpful for the project implementation. This was mainly performed through communication with the NEEMO/Elmen EEIG monitor, Daniel Svoboda and project advisor Malgorzata Piecha. They answered all our factual and financial questions. If necessary, our questions were addressed to the representatives of EASME, or CINEA.

Changes due to amendments to the Grant Agreement

One amendment (Amendment No.1) was issued within the project and signed by all the beneficiaries (last signature 9. 6. 2023). There were two topics of the amendments: Financial exchange between TUL (coordinator) and DIAMO (beneficiary) in the amount of 12,602 € - the EU LIFE grant budget from TUL to DIAMO, and the national co-financing source from DIAMO to TUL. This exchange of sources was due to additional work on the investment needed, which could not be paid from the co-financing source, and DIAMO had no EU LIFE sources in the appropriate amount available at that time.

Additionally: The Polish beneficiary Jaworzno (public body) and Czech beneficiary PWT (private enterprise) obtained new co-financers (public third party). The Jaworzno received 118,362 EUR from NFOSiGW - National Fund for Environmental Protection and Water Management, and PWT received 750 thousand CZK from the Ministry of the Environment of the Czech Republic.

6. Technical part

6.1 Technical progress, per Action

<table>
<tr><td colspan="2">A.1 Preparatory of Hajek construction</td></tr>
<tr><td>Foreseen start date: 01/2020</td><td>Actual start date: 15/01/2020</td></tr>
<tr><td>Foreseen end date: 03/2020</td><td>Actual end date: 31/03/2020</td></tr>
<tr><td colspan="2">The work has been done mainly by PWT, DIA, and TUL</td></tr>
<tr><td colspan="2">Action description:
Action A1 involved negotiations with authorities in the permitting process at the Hajek site related to issuing official statements and decisions of the authorities. The process began during the project preparation phase. The following activities were carried on:
- during kick-off, all project partners were informed about the Hajek site and planned activities in the next period,
- necessary Documentation and Building permits were collected, and conditions for building the passive remediation system of HCH-contaminated mine water resulting from the building permit were set,
- Wetland+® construction plans were repeatedly discussed and finalized,
- Site monitoring was prepared, and initial monitoring was carried out.</td></tr>
<tr><td colspan="2">Action outputs achieved:
The following permits and decisions were received (documentation for the following permits and decisions was prepared by PWT in close cooperation with DIAMO):
☒ Building permit Ref. No. ŽP/19945/18
☒ The Decision of the Municipal Office of Ostrov nad Ohří to extend the building permit until 31 December 2021.
☒ DIAMO completed the building documentation for tendering the “Passive Remediation System of HCH Contaminated Mine Water”. The contract with the winner, DEKONTA Company, was signed on 4 June 2020.

The outputs are summarized at deliverable DA1 and milestone MA1.</td></tr>
<tr><td colspan="2">Modification and deviation of the action: No modifications and deviations</td></tr>
<tr><td colspan="2">Major problems (drawbacks): No major problems were encountered</td></tr>
<tr><td colspan="2">Complementary action outside LIFE: DIAMO carried out complementary actions at the P1 site – preparation of the inflow system to the wetland installation, construction of a load-bearing wall, construction of a horizontal well as a source of drainage water situated above the inflow point, and construction of a new access road. Actions help smoothen the implementation of the A1 action and the P1 system construction (action B1).</td></tr>
<tr><td colspan="2">Continuing the action after the end of the project: Due to the nature of action A1 and the permitting and decision processes, no continuation of action A1 is expected after the end of the project.</td></tr>
</table>

Illustrate the actions: Hajek site complementary actions – left image: construction of the road; right image: horizontal well for drainage water collection.

A.2 Preparatory of Jaworzno construction	
Foreseen start date: 01/2020	Actual start date: 01/2020
Foreseen end date: 09/2020	Actual end date: 30/07/2021
JAW was a responsible beneficiary supported by GIG, PWT and TUL	

Action description:

The preparatory work and permitting process for P2 construction. Gathering and structuring of the existing information included inventories of land ownership, existing infrastructure, historic records of HCH waste collection, the existing data on contamination of soil, water, groundwater, sediments and vegetation; the existing plant coverage with particular focus on the number of tree; the possible presence of protected species; current and future land use plans (territorial plan); current extent of contamination, and utilisation of the results of C1 monitoring activity (the monitoring campaign took place on 19 August 2020).

Action outputs achieved:

The subsequent action A2 included tasks:

- "Geodetic measurement of the prototype implementation area and inventory of the existing plant coverage needing a permit for felling trees and shrubs"
- "Development of maps for design purposes", maps for design purposes were prepared in May 2020 by Przedsiębiorstwo Usług Geodezyjnych Jerzy Morito from Jaworzno.
- "Geodetic destination of the prototype implementation area and inventory of the existing plant coverage needing a permit for felling trees and shrubs". It was performed in May 2020 by Eurofins OBiKŚ Polska Sp. z o.o. from Katowice.
- "Development of the documentation necessary to the notification of the construction works" was completed in July 2020 by JAW.
- Information was compiled in a database in Jaworzno. GIG staff were heavily involved in gathering extensive information from the previous projects FOKS (2008-2011) and AMIIGA (2016-2019) and from the first monitoring campaign of the LIFEPOPWAT project.
- "Implementation of the database with an interactive map" was completed in November 2020 by Smart Geomatic Leszek Litwin from Gliwice.

List of obtained permits:

☒ Permit for felling trees and shrubs (Issuing authority: Marshal of the Silesian Voivodeship; month of release: December 2020);

☒ Notification of the execution of the construction works (Issuing authority: Mayor of Jaworzno; month of release: July 2020);

☒ Conditions for the power connection (3kW) (Issuing authority: Tauron Dystrybucja SA; month of release: July 2020).

The outputs are summarized at deliverable DA2 and milestone MA2.

Modification and deviation of the action:

Most of the tasks planned under A2 were completed within the foreseen deadline – by September 2020. But due to the COVID-19 situation in Poland, and permission for felling trees and shrubs delay, the actual end date of the action was postponed. This delay does not affect other project actions.

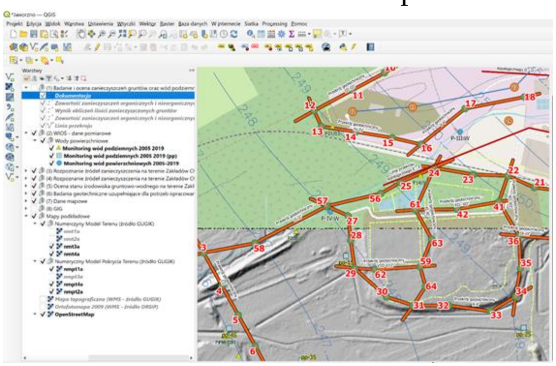
Major problems (drawbacks): Due to the long implementation time of the new public procurement regulations (published in Poland at the beginning of 2021) and the creation of internal rules in force at the Municipal Office in Jaworzno (until March 2021), it was decided that the felling of trees and shrubs would be added to the tender for the execution of the P2 prototype within project action B3.

Complementary action outside LIFE: No actions.

Continuing the action after the end of the project:

The City of Jaworzno plans to develop the database further by supplementing it with new information related to the contamination of HCH or other dangerous substances.

Illustrate the actions: Left image: internal meeting organized in Jaworzno on 5 March 2020, right image: screenshot from the database with an interactive map



B.1 Installation of P1 at the Hajek site	
Foreseen start date: 03/2020	Actual start date: 3. 8. 2020
Foreseen end date: 03/2021	Actual end date: 15.12.2021
The work has been done by DIA mainly with the support of PWT and TUL	

Action description:

In February 2020, the implementation documentation was prepared. Based on the documentation, the tender for the supply of the project was launched on 7 April 2020. The contract with DEKONTA was signed on 4 June 2020. Commencement of work was on 3 August 2020.

The expected end of Activity B1 was extended due to external factors affecting implementation. Complementary actions carried out by DIA (not funded by the project) were the preparation of the inflow system to the wetland installation, construction of a load-bearing wall, construction of a horizontal well as a source of drainage water, and construction of a new access road postponed the actual start of the B1 action. These actions help smoothen the implementation of the B1 action and the P1 system construction. The second reason was a slight delay in the tender announcement due to the COVID. Due to the bearing capacity of the bedrock, there was more earthwork than planned, and the schedule for the sedimentation tanks and the slag-filled tanks was also delayed and the tanks were not made of precast concrete but were cast in concrete as monoliths. There was also a change in the specific weight of the Fe material concerning its porosity (an increase compared to the pilot project). The aim was to stabilise the permeation of water through the filings and to delay future replacement of the filings due to low permeability. Other changes were made compared to the construction implementation documentation. The most important include different levels of soil excavation, the introduction of more gravel sub-base, the technical design of PRB tank roofing, slight enlargement of the PRB tanks, installation of service bridges, and the end shaft changed from the initially standardised parts to monolithic. All these changes led to better functionality of the system compared to the original design documentation and did not lead to an increase in the contract price. The changes did not affect the final date for handing over the work to the client (15 September 2021).

After that, documents were prepared for a trial operation permit, which the Ostrov nad Ohří Municipal Authority issued on 16 November 2021 (Ref: ŽP/76429/21). The decision came into force on 4 December 2021. The system was operated in a test mode until the end of 2023, when the permanent operation permit was issued.

Action outputs achieved: The main output of the action is a fully functional P1 system at the Hajek site, which was further tested and modified (action B2).

The outputs are summarized at deliverable DB1 and milestones MB1, MB2 and MB5.

Modification and deviation of the action: All technical modifications made were described above. The duration of the action was postponed and extended (see above). This extension had no significant influence on the project outputs.

Major problems: Problems were caused by the COVID-19 situation, mainly due to the effect on the markets (price increase, extension of delivery time, etc.). As the rules of public tenders do not allow an increase in the price of performance beyond a specific limit, part of the works (e.g., roofing of the PRB tanks) was performed by DIAMO and not by the contractor who was initially supposed to perform it according to the contract.

Complementary action outside LIFE: Preparation of the inflow system to the wetland installation, construction of a load-bearing wall, construction of a horizontal well as a source of drainage water, and construction of a new access road.

Continuing the action after the end of the project: The Wetland+® remediation system will run in a long-term perspective after the end of the project.

Illustrate the actions: Photo from the wetland system building.

B.2 P1 Operation and Validation	
Foreseen start date: 01/2021	Actual start date: 15. 9. 2021
Foreseen end date: 12/2023	Actual end date: 31. 12. 2023

The work has been done by TUL, with the contribution of DIA and PWT

Action description:

The P1 prototype passed tightness tests and entered the trial operation period on 15. 9. 2021. Some minor construction works, such as the connection of the mine heap drains into one inspection shaft, installation of roofing on the pools of module B, tubes eliminating module A, or installation of automatic flow measurements and a data-logging system, were performed later on in 2021 and 2022 as a part of the system refinements. The system has worked without interruption throughout the period and maintained extreme water flows up to 5 l/s (extending the planned capacity).

Together with system operation, some regular activities were provided to check, optimise, and validate its functions:

- system inspection and maintenance (regular checking of all ducts permeability, sediment thickness in module A, vegetation status in modules C and D),
- the maintenance-management plan (DB8) was prepared,
- collection of photo and video documentation of the system from the ground and by drone cameras for the evolution of vegetation changes during the period,
- monitoring of the performance of the individual modules A through D via physicochemical parameters (pH, ORP, conductivity, dissolved O_2); chemical water composition, including HCH/ClB/CPhF contamination; bacterial functional genes for aerobic HCH degradation.

Action outputs achieved:

During the system testing period, 25 sampling campaigns were performed. Based on the analysis, the following results are presented:

- Fe^{2+} in the inlet drainage water precipitates as fine structure, which cannot effectively sediment in the A modules. Moreover, the inlet water has a relatively low dissolved oxygen content (an added value of the horizontal well constructed as a complementary action). Therefore, it was decided to exclude module A from the system for better performance of the B modules.
- The B modules were covered with protective shielding to prevent the entry of organic materials (leaves) and keep ORP low.
- System efficiency significantly depends on the flow. If the flowrate is below 2.0 l/s, the efficiency is over 84% for HCH removal. Moreover, the efficiency increases due to wetland plant growth in the D module. This growth is expected to continue.
- On 20. 12. 2023 DIAMO received the approval of the building permit and the transition of the P1 system to permanent operation.

The results are summarized in DB7, DB8, DB9, and milestones MB7 and MB8, as well as in the scientific papers and presentations at conferences (see appropriate part).

Modification and deviation of the action: There was no modification of this action. A few changes were made, mainly more performance monitoring campaigns. The system was repeatedly updated, as planned.

Major problems (drawbacks): The migration of iron precipitates downgradient from module A was identified as a significant issue. The module A was excluded.

Complementary action outside LIFE: None.

Continuing the action after the end of the project: The maintenance-management plan was prepared, which supports the system's performance in the following years. There is no necessity for iron chip exchange in module B in the coming period. Similarly,

removing the sediment from module A is not an issue. Also, the harvesting of wetland shrubs is not planned in the coming years.
Illustrate the actions: The constructed wetland system P1 in operation.  

B.3 Design and Installation of P2 at Jaworzno	
Foreseen start date: 03/2020	Actual start date: 1. 3. 2020
Foreseen end date: 12/2021	Actual end date: 27. 12. 2022
TUL organized the meeting to solve the problems JAW presented; PWT designed and re-design the system for the tenders, GIG supervised the construction and reported the issue, AU participated in the design and re-design.	
Action description: The construction of P2 system at Jaworzno site. During the P2 construction, several problems occurred, which resulted in significant delays in its completion and commissioning. The main problem was connected with the selected construction company, which whom the contract was finally terminated and the new tender with an updated design was issued. The new contractor (EKOMAR Sylwester Szcześniak from Maryno) finished the building on 27/12/2022. The system was tested, but the water flow and monitoring started in March 2023. Fortunately, the wetland system (module D) was constructed by the first contractor at the beginning of the construction period and kept flooded during the whole period, so the wetland plants were already grown. A detailed description of the timing issues is summarised at DB4.	
Action outputs achieved: The P2 system was designed on a significantly smaller scale compared to the P1 system. The reason for this was the different composition of the contaminated water, the different environments, and the different installation objectives, where the P2 system was to test the adaptability of the Wetland+® system to varying compositions of contaminants and other environments. Also, the budget for the system construction was significantly smaller. The solar electric source for the system operation was tested as well. The outputs are summarized at deliverable DB4 and milestones MB4 and MB6.	
Modification and deviation of the action: The number of trees and shrubs to be cut down was insignificant decreased, the steel containers were replaced by the concrete ones. The deviation of the schedule is described above. However, because the system's primary objectives were to see the system adaptation to another type of environment and composition of contaminated water, as well as the use of solar sources for the system operation, the delay in the system construction did not affect the project results.	
Major problems (drawbacks): The difficulties during building were described above.	

Complementary action outside LIFE: The City of Jaworzno discussed a particular act on large-scale contaminated areas, legislation allowing action to be taken to solve problems of waste accumulated in Jaworzno, with the Ministry of Climate and Environment.
Continuing the action after the end of the project: The potential for a large-scale system installation at Jaworzno is under discussion with the municipality. The system operation and monitoring will continue and be organised by JAW, GIG and TUL.
Illustrate the actions: P2 system construction works.  

B.4 P2 Operation and Validation	
Foreseen start date: 01/2022	Actual start date: 28. 12. 2022
Foreseen end date: 12/2023	Actual end date: 31. 12. 2023
GIG and JAW have done the fieldwork, TUL environmental and performance monitoring, and PWT participated in data interpretation.	

Action description:

The P2 prototype passed tightness tests and entered the trial operation period in March 2023. The trial operation lasted nine months (from March 2023 till the end of November 2023). The prototype operation was divided into two stages. The 1st stage lasted from the beginning of April until the end of August 2023, while the 2nd stage of operation lasted from September to November 2023. This staging was due to the ZVI module's air flushing, which occurred at the end of August and caused a significant increase in water flow through the system (the flow rate increased from value 0.04 l/s to 0.25 – 0.4 l/s).
During operation, two water sources differing in the HCH and POP contamination levels were supplied to the prototypes. During the operation of the P2 prototype, direct current (DC) was applied to ZVI module (B) to prevent ZVI oxidation and provide an alternative power reduction medium.

Action outputs achieved:

During the system testing period, 21 sampling campaigns were performed. Based on the analysis of the results, the following results about the system modules are presented:

- The initial efficiency of HCH removal was low, due to low HCH input at the inlet. The system was not fully set-up, and the results are not reproducible.
- The HCH removal efficiency increased from June to the end of July 2023 up to 97%. The flow rate in this period was low, between 1.0 to 2.5 l/min.
- In the 2^{nd} stage of the test, when the flow rate increased to over 6.0 l/min (i.e. residence time decreased), the HCH removal efficiency decreased and varied between 46% and 81%. So, in this setup, the system cannot clean water (flow rate is insufficiently high) but can remove about 2-4 g of HCH/a.
- The ClB removal efficiency ranged from 56% to 93%.

- The P2 system also showed relatively high efficiency for removing other POP compounds, where at the low flow, the overall efficiency is above 80%, and for the increased flow, it is about 40%.

The results of this action are summarized in DB6, DB10, DB13, and milestone MB9.

Modification and deviation of the action: No modifications were made.

Major problems (drawbacks): The major problem was to keep the constant inlet concentration of HCH in the system. For relatively low flow, the fluctuation in the inlet concentration was relatively high; therefore, many monitoring campaigns were needed.

Complementary action outside LIFE: No direct complementary action took place.

Continuing the action after the end of the project: The maintenance-management plan for the P2 system was prepared for following years.

Illustrate the actions: P2 system final set-up.


B.5 Prototype Implementation Assessment	
Foreseen start date: 01/2023	Actual start date: 1. 1. 2023
Foreseen end date: 12/2023	Actual end date: 31. 12. 2023

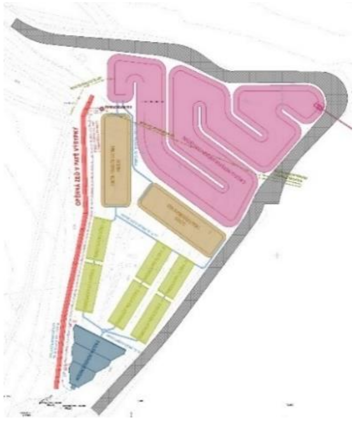
TUL made the assessment with contribution of the other beneficiaries.

Action description:

The pilot installation of Wetland+® technology at both sites was monitored for an extended period, and based on this monitoring, a few system modifications were carried out to increase system efficiency. During this period, all the technology parts of the Wetland+® system were assessed for their particular contribution to overall system performance and their modifications. The results have been generalized for similar installations in variable environmental conditions, HCH contaminations, and water quality. In particular, results and experiences determined at the two sites (Hajek and Jaworzno) were assessed and generalized. While the Hajek site was ready for installation at the beginning of the project, the Jaworzno site was established from the beginning (including the permissions, legislations and local conditions). This helps with system installation on the other potential sites. All these experiences are summarized in the Technology Guide (DB11).

Action outputs achieved:

All determined experiences with the system installation on both sites are summarized in a Technology Guide (DB11). The guide specifies the optimal and reliable conditions for the technology implementation at any other site (replication process). The process was tested on three sites (see B6).

The particular parts of the guide are concerning about legal requirements, mechanisms of HCH removal, description of the Wetland+® technology units and their roles, roles of lab tests and field pilot tests, system dimensioning, operation monitoring and environmental monitoring to evaluate the system's performance, estimation of the capital, operating and maintenance costs, and management and maintenance plan. The outputs are summarized at deliverable DB11 and milestone MB10.
Modification and deviation of the action: No modifications and deviations.
Major problems (drawbacks): No major problems were encountered during action B5.
Complementary action outside LIFE: No complementary action.
Continuing the action after the end of the project: The potential candidate sites for the system installation will be put into site assessment.
Illustrate the actions: Technology for field testing and scheme of the Wetland+® system.  

B.6 Replication and Business Planning	
Foreseen start date: 01/2020	Actual start date: 1. 1. 2020
Foreseen end date: 12/2023	Actual end date: 31. 12. 2023
SER coordinated the action, with the contribution of PWT, GIG, DIA and TUL.	
Action description: Replication is an essential activity for the dissemination of the project results. To support the replication, notice boards, leaflets, presentations at conferences and scientific papers describing the technical specifications of Wetland+® were prepared. The replication and business planning cover broad tasks summarized in the Technology guide that supports external consultants in site management design in a way that supplements their know-how. During the project, many potential sites were selected, described in some detail and assessed. The list of more than 30 sites is provided, and the most relevant sites (with appropriate information, with existing contacts to site owners/providers, etc.) were investigated in more detail.	
Action outputs achieved: DB2 – prospect for replication of Wetland+® listed the potential candidates for replication of Wetland+®, which were collected during the whole project period. DB3 – the most relevant candidate sites were put into the replication conveyor belt. The project defined the system and how the potential candidate sites will be treated. DB5 – service package for clients of Wetland+® defines above-mentioned steps in detail with relevant designs of the experimental set-ups. DB12 – replication plan shows three selected potential sites, which were treated on the replication conveyor belt, namely Pais Basco/Jata landfill (Spain), Aragon /Sabinanigo	

(Spain) and Libis (Czech). Two other sites are considered – Galicia /Porrino (Aragon) and Westerelgen (Germany).
DB14 – The business plan estimates financial issues concerning the replication of the technology. For the beneficiaries, it is an expected turnover that could be realized in the next three years (2024-2026) and probably after 2026.

Besides these deliverables, two milestones, namely MB3 and MB11 were prepared.

Modification and deviation of the action: No modifications and deviations.

Major problems (drawbacks): No major problems were encountered during action B5.

Complementary action outside LIFE: SERPOL has developed a new in-situ process to address lindane-impacted aquifers and the vadose zone. The Wetland+® remedial system can easily support such technology.

Continuing the action after the end of the project: The LIFEPOPWAT team will lead the promotion of wetland treatment and target sites where Wetland+® may be relevant. EU complementary funds would be helpful to stakeholders who test the technology.

Illustrate the actions: Screenshot of the virtual meeting with URA concerning the Barakaldo sites in Spain; 3D model of Wetland+® system in Hajek (scale 1:87)

C.1 Monitoring of Environmental Impact	
Foreseen start date: 01/2020	Actual start date: 1. 1. 2020
Foreseen end date: 12/2023	Actual end date: 31. 12. 2023
While TUL was responsible for organizing the sampling campaigns, making chemical and biological analysis, and sampling at Hajek and for environmental monitoring at Jaworzno, GIG was sampling in Jaworzno, and AU helped with data interpretation; DIA and JAW collected historical data about the site's monitoring.	
Action description: This activity comprises field sampling events at sites spread over the project duration. Sample analysis was performed mainly at the accredited laboratories of TUL. In-house water analysis at TUL utilised a solvent-free green analytical technique, SPME. Besides HCH and related transformation products, major anions, cations, and physicochemical data were recorded. Organochlorinated pesticides POPs (e.g., DDT, endosulfan) were also determined for the Jaworzno site. Since the installation of Wetland+® technologies at both sites, the environmental matrices have been positively influenced by the system that treats the effluent from the HCH waste dumps. There are two main types of environmental impact data collected, i.e., chemical and biological analysis (of groundwater, surface water, sediments, and biomass of plants and	

animals) and biodiversity surveys (of benthic invertebrates, diatoms, and plants). In addition, flow rates were measured to quantify the annual mass loads by HCH and ClB.
During the project, 25 and 21 sampling campaigns took place at Hajek and Jaworzno sites for performance monitoring, respectively. Moreover, 8 campaigns were elaborated for the environmental monitoring of site surroundings, including monitoring of water streams and animals. A new method for groundwater monitoring was sufficiently tested for measuring HCH concentration in tree samples. Overall, 1,896 samples were analysed at TUL laboratories with some tens more at other laboratories.

Action outputs achieved:

Hájek site

The Wetland+® P1 demonstration prototype has treated drainage water since its commissioning for 809 days (~27 months). During this trial period, HCH, ClB and ClPh at the inlet to the P1 prototype varied from 52 to 265 µg/l, from 103 to 2312 µg/l, and from non-detect values to 75 µg/l, respectively. Simultaneously, the water flow rate ranged seasonally from 0.7 to 5.0 l/s. After the installation of the prototype, the system was repeatedly maintained and modified to improve its efficiency. The removal efficiency of HCH ranged from 53.5% to 96.9% (83.9% on average), depending of the flow, which seasonally exceeded the constructed maximal flow rate of 3 l/s. If the flow rate is below 3 l/s, the average efficiency is 86.9%. Similarly, for ClB and ClPh efficiency ranged from 71.6% to 100% and 15.7% to 100%, respectively. And for the flow rate below 3 l/s the average efficiency was 96.4% and 84.5% for ClB and ClF, respectively. Additionally to chlorinated organic compounds, the P1 prototype removed a significant amount of dissolved iron with an efficiency ranging from 79.3% to 99.9%.
Removal efficiency was not uniform for individual HCH isomers but exhibited higher values for α, γ, δ then β = ε. Consequently, while δ-HCH isomer dominated the inflow, ε-HCH prevailed in the outflow from the P1 prototype (66% of all HCH isomers). However, ε-HCH is not listed in the sum of HCH isomers in Government Regulation 401/2015 Coll. on indicators and values of permissible pollution of surface water and wastewater. If we did not consider it, then the highest represented isomer would be δ-HCH. The average outflow HCH concentration drops to 1.3 ug/l.
The environmental monitoring showed that the operation of the P1 prototype resulted in a substantial reduction in HCH mass discharge to Ostrovsky Creek, namely from 23 - 25 g/day to 0.3 – 11.3 g/day, marking an approximate 51% to 99% decrease. If the flow is below 3 l/s, the discharge is lower than 3 g/l, about an order of magnitude lower than the inflow. The numbers of phytobenthos (Diatoms) species, commonly used biomarkers of the aquatic environment, were annually investigated on both sites (160 samples overall) to prove an improvement in surface water quality.
The P1 prototype treated approximately 130,800 m^3 of contaminated water within the test operation and removed about 12.8 kg of HCH, 68.5 kg of ClB and 1.2 kg of ClPh. In addition, the P1 removed approximately 2,000 kg of Fe in the form of oxo-hydroxides and 212 kilograms of Mn.

Jaworzno site

Due to problems during the construction, the trial operation of the P2 prototype lasted only 12 months (from January 2023 till the end of December 2023). During that time, a few tests were running. The efficiency of HCH removal from April to May 2023 was low, most likely due to a low and unstable HCH concentration at the inlet. However, the efficiency gradually increased from June to the end of July 2023, when the concentration at the inlet was higher. A very high HCH removal efficiency (83% to 97%) was observed.

In the last part of the test, the HCH removal efficiency decreased significantly when the flow rate increased.
Similarly as P1 site, the removal efficiency was not uniform for individual HCH isomers. Removal exhibited the highest value for γ, then for α, δ, then for β and the lowest one for ε. Consequently, while all isomers are present in the inflow, δ-HCH prevailed in the outflow from the P2 prototype. The P2 prototype in Jaworzno eliminated the following mass of pollutants: 283 mg of HCH, 17.36 mg of ClPh and 1,623 mg of ClB. In addition, other POPs pollutants such as DDT, β-endosulfan, methoxychlor, and trichloroethylene are present. They were not studied in detail, but their overall removal efficiency was between 57% and 91%. So, about 1,204 mg of POPs was eliminated during this short period.
Surface water, groundwater and phytobenthos monitoring established a baseline of environmental quality at the Jaworzno site and a future benchmark for assessment of the long-term efficiency of the full-scale remediation.

Number of samples (total for Hajek and Jaworzno):

Matrix	**2020**	**2021**	**2022**	**2023**	**subtotal**
Water	223	100	220	440	**983**
Soil			12	9	**21**
Trees	128		49		**177**
Sorbents	110				**110**
HCH fractions and metabolites	20				**20**
Water - laboratory test with ZVI	60				**60**
sap of trees		18			**18**
Moss		30			**30**
invertebrates			9		**9**
Plants			162	304	**466**
Biochar				2	**2**
Total	**541**	**148**	**452**	**755**	**1,896**

The outputs are summarized in deliverables DC2, DC4, DC6 and DC8.

Modification of the action: Due to the necessity of very intensive performance monitoring of both systems, the number of sampling campaigns and samples significantly exceeded the projected numbers. Financial sources were allocated from other activities.

Major problems (drawbacks): There was no problem with the action.

Complementary action outside LIFE: Results of monitoring were presented at workshops and conferences not covered from the project.

Continuing the action after the end of the project:
Environmental monitoring of the site surroundings, as well as the monitoring of the installed Wetland+® technology, will continue after the end of the project, namely minimal 6 annual sampling campaigns at P1 site and 4 at the P2 site.

Illustrate the actions: Monitoring of the diatom community.

<table>
<tr><th colspan="2">C.2 Monitoring of the Social-Economic Impact</th></tr>
<tr><td>Foreseen start date: 01/2020</td><td>Actual start date: 1. 1. 2020</td></tr>
<tr><td>Foreseen end date: 12/2023</td><td>Actual end date: 31. 12. 2023</td></tr>
<tr><td colspan="2">TUL coordinated the work, and TUL was responsible for P1 site, GIG for P2 site and for LCA analysis. DIA and JAW were organising inputs from the sites (relevant stakeholders), and AU and SEP gave EU input data for comparisons.</td></tr>
<tr><td colspan="2">Socio-economic impacts had the broad aim of investigating whether or not Wetland+® offers gains in socio-economic performance over conventional WWTP or the no intervention scenario in site management (status quo). The assessment was made using two methods – questionaries on socio-economic impacts and LCA analysis.

It was applied on both project sites. Sustainability assessment considers impacts on society and the economy holistically and can be linked to environmental, economic, and social indicators assessment. The approach is qualitative, based on ranking the three management options against a range of sustainability criteria (see ISO 18504:2017 Sustainability Assessment based on Soil Quality - Sustainable Remediation). The proposed framework builds upon the 15 broad categories of indicators addressed by the SuRF-UK Indicator checklist, which revolves around three main elements of sustainable development: environment, society and economy. The ranking was on the basis 1 best to 3 worst. Each ranking was supported by lines of evidence also recorded in the spreadsheet.

Framing outcomes for the sites including several steps and appropriate outcomes:
1. Description of decision requirements - The question to be addressed is whether there is likely to be a sustainability gain from treating surface water contaminated by HCH (and daughter compounds).
2. Description of the project - Options to be compared: Wetland+®, conventional wastewater treatment plant, and hypothetical no intervention.
3. Description of constraints – The site is far from any infrastructure. There is no water service, gas, or public safety (and site security), as the location is easily accessible.

Criteria included in the site assessment are:
Environmental – Emissions to air, soil and ground conditions, groundwater and surface water, ecology, natural resources, and waste.</td></tr>
</table>

Economic – direct and indirect economic costs and benefits, employment and employment capital, induced economic costs and benefits, project lifespan and flexibility. Social – human health and safety, ethics and equity, neighbourhoods and locality, communities and community involvement, uncertainty, and evidence. The life cycle assessment started at Hajek, where the full-scale remedial technology was applied. The life cycle assessment was carried out in four stages: • defining the purpose and scope, including setting the boundaries of the systems (construction and operation), the functional unit 1m^3 of treated water, and the 25-year lifetime of the systems, • inventory analysis (Life Cycle Inventory – LCI), i.e. collection of input data for both systems within construction and operation stages, • impact assessment (Life Cycle Impact Assessment – LCIA), i.e. ReCiPe2016 method at midpoint and endpoint level (Huijbregts et al. 2016), • interpretation (by SimaPro software). TUL coordinated the work, and TUL was responsible for socio-economic assessment at the P1 site. GIG was similarly responsible for the socio-economic evaluation at the P2 site and for LCA analysis. DIA and JAW were organising inputs from the sites (relevant stakeholders), and AU and SEP gave EU input data for comparisons. All project beneficiaries discussed the results.
Action outputs achieved: The assessments compared Wetland+® with the conventional WWTP and no-intervention scenario. Wetland+® ranked best for sustainability overall. After the final stage, including external stakeholder consultations, Wetland+® outranked all options across 10 out of the 15 headline sustainability categories and was equal first for four of the remaining five. In only one category, uncertainty and evidence, did it rank behind another option (WWTP), which was entirely predictable for an emerging technology is compared to an established one. LCA analysis compared both systems: Wetland+® and WWTP. The WWTP system is characterized by a much higher environmental burden, both as a whole and within subsequent damage categories such as human health, ecosystems or resources. Namely, the Wetland+® scored 8 mPt/FU, while the WWTP system 96 mPt/FU. The outputs are summarized at DC1, DC3, DC7, and DC5 deliverables. There are also two milestones, namely MC1 and MC2 related to the action.
Modification and deviation of the action: There was a shift in the socio-economic survey due to the COVID-19 situation and the impossibility to contact stakeholders.
Major problems (drawbacks): Mapping Wetland+® against treatment alternatives to enable a comparative sustainability assessment has been a protracted process at Jaworzno. The outcome is good but took time to reach.
Complementary action outside LIFE: No complementary action.
Continuing the action after the end of the project: The technology will be used in the next stage to carry out the third stage of a socio-economic assessment at the second project site.
Illustrate the actions: System boundaries, Interpretation radar plots (working version)

<table>
<tr><td colspan="2">D.1 Communication and Dissemination</td></tr>
<tr><td>Foreseen start date: 01/2020</td><td>Actual start date: 1. 1. 2020</td></tr>
<tr><td>Foreseen end date: 12/2023</td><td>Actual end date: 31. 12. 2023</td></tr>
<tr><td colspan="2">All beneficiaries were responsible for the project dissemination by the leadership of AU.</td></tr>
<tr><td colspan="2">Action description:
Regarding protecting intellectual property, the designation Wetland+® differentiates the development of other wetland technologies. The use of Wetland+® has been strengthened and branded by using the term in publications and dissemination activities.
The Project Communication & Dissemination Plan (MD1) was created immediately in the project's first months. This plan includes a communication strategy, target audience, and tools like the logo, graphic project identity, templates, and web pages (DD1). The Plan was checked twice during the project (DD4: Interim report on project communication and dissemination and DD7: Final report on project communication and dissemination).</td></tr>
<tr><td colspan="2">Action outputs achieved:
The action has been achieved through scientific meetings and direct contact with persons responsible for or with connections to known contaminated sites. In the first half of the project, the COVID-19 pandemic affected the frequency of scientific events. It has been possible to attend virtual meetings in which the project has been presented to scientists and stakeholders. Of the events attended, WETPOL 2021 deserves a particular mention. This was a specialist meeting with around 400 attendees, where the consortium held a specific workshop on HCH pollution and removal using Wetland+®.
The list of all conferences, the PhD course, where the project was presented is attached to DD7 deliverable (MD2). At the Wetpol 2023, three presentations on Wetland+® technology and potential clients were contacted. As a result of the conference, two papers for a special issue of the STOTEN journal are being prepared.
Besides the presentation at scientific conferences, five scientific papers were prepared and are either published or in the process of publishing. The List of potential replication sites (DD3), and Ranking report of prospective replication sites (DD6) were prepared. Technical supporting material (DD5: Recommendation Note) and non-technical material (DD8: Laymen´s report; and also in Czech) were also elaborated to describe the technology. The other outputs are DD2, and milestone MD3.</td></tr>
<tr><td colspan="2">Modification and deviation of the action: No</td></tr>
<tr><td colspan="2">Major problems (drawbacks): The COVID-19 pandemic has restricted to participate in public events, but this drawback was made up during the project's second half.</td></tr>
<tr><td colspan="2">Complementary action outside LIFE: The team has reached contact to find synergies with EU-financed projects using wetland technology, namely PAVITR, LIFE INTEXT,</td></tr>
</table>

LIFE GREEN ADAPT, NICE, MULTISOURCE, JPI-NATURE, LIFE NIRVANA and TOXICROP.

Continuing the action after the end of the project: The team plans to publish other scientific papers and present the project results on other conferences in the next years.

Illustrate the actions: TV interview at the site; meeting with stakeholders.

E.1 Project management

Foreseen start date: 01/2020	Actual start date: 1. 1. 2020
Foreseen end date: 12/2023	Actual end date: 31. 12. 2023

The work was coordinated by TUL (namely by the project coordinator, Prof. M. Cernik) and the financial manager (Pavla Svermova).

Action description:

Detailed action description is in 5. Administrative part of this report. A primary aim of this action was to ensure the smooth implementation of the project activities under the planned (or updated) schedule to reach all project objectives, deliverables and milestones. The action had the following activities:

- Nomination of the PM bodies
- Project progress meetings
- Green procurement principles
- After-LIFE plan

Action outputs achieved:

All documents related to project management are on project websites (https://cxi.tul.cz/lifepopwat), including the project boards, photos from the sites, all deliverables and milestones, newsletters, minutes of the meetings, etc. Particular deliverables of this action are:

DE1 – A handbook of LIFEPOPWAT green procurements, which defined principles related to green principles, was prepared at the beginning of the project.

DE2 and DE4 – After-LIFE plan (early draft and final version) describing actions in the sustainability period of the project.

DE3 and DE5 – project reports (Mid-term and this Final report)

Also ME1 and ME2 were prepared.

Modification and deviation of the action: No serious modifications were needed.

Major problems (drawbacks): No significant problems appeared.

Complementary action outside LIFE: No actions.

Continuing the action after the end of the project: see the After-LIFE plan.

Illustrate the actions:

6.2 Main deviations, problems and corrective actions implemented

Although the project proceeded broadly as planned, there were several points where it was delayed or modified. It can be divided into two main factors, i.e., COVID-19 and others.

The COVID-19 situation mainly affected Action D1 - Dissemination Planning and Execution in the first two years of the project duration. Several planned conferences and meetings with potential clients or followers were postponed. This, however, did not significantly affect the final dissemination activity because, in the second period the dissemination of the project took place more intensively. There was also a shift in the socio-economic survey due to the impossibility of contacting stakeholders. The change did not influence the project outputs.

The most significant of the other deviations was a delay in the P2 system construction in Jaworzno. The delay affected the testing period of P2 installation but did not significantly affect the project outputs. The system's primary objectives were to see the system adaptation to another type of environment and composition of contaminated water, and the use of the solar source for the system operation, which all was successfully tested in the remaining period.

Delays in individual actions:

- A2 Preparation of Jaworzno construction: Because of problem with receiving the permit for felling trees and shrubs, the task was postponed and added to the tender for the execution of the P2 prototype within project action B3.
- B1: Installation of P1 at the Hajek site: The system completion was postponed due to technical problems like lower stability of the bedrock, delays in parallel activities realised outside of the project, and due to COVID-19 situation. This extension of the construction period and minor changes made in the building design eliminated problems that would have arisen after the completion of construction. Such delay had no significant influence on the project outputs.
- B2: P1 operation and validation: More performance monitoring campaigns were needed to improve the system performance and to check the system performance at the extreme flow periods. The system was also repeatedly modified to improve its efficiency. Finally, the A module was excluded from the treatment process, and a new tube connection was installed.
- B3: Due to problems in the purchase of steel containers (the lack of availability on the market due to the COVID-19 pandemic), the concrete containers or mix steel with concrete were used.

6.3 Evaluation of Project Implementation

The project had five basic actions with the following aims, outputs and methodologies:

(A) Preparatory action aimed to provide all preparatory work to enable smooth implementation of the technology at two pilot sites. The methodology was mainly to check and complete all permits necessary for the implementation, update the situation on both sites based on monitoring, and start the tendering process to select subcontractors for the building. The methodology was successful, and action resulted in the preparation of the building on both sites. At the Hajek site, this was smoother, mainly due to the high degree of preparedness (the permitting) and accompanying actions in progress. In Jaworzno, where the permitting process was not as developed, the preparatory process was not so efficient and fast. This was due to unexpected problems (COVID and subsequent problems). In general, lessons learned that it is recommended to have all the necessary permits ready before the start of the project. So, unexpected issues can prolong such preparatory action, but the subsequent actions should have a time margin to cover such problems. The cost-effectiveness of addressing individual actions can be expressed in terms of the number of man-months required to complete the tasks of those actions. MM is a more appropriate indicator because the total cost of addressing individual actions is incommensurable. For example, the installation of prototypes P1 and P2 at the sites are investments, they were spent in action B, but without this investment the other subsequent actions could not take place. Action A ran for a relatively short period of time (including the necessary extension) and represents 13 MM, or 4% of the total MM of the project. This corresponds to planned MM in the project proposal of this action 4%.

(B) Implementation actions focussed on installing the Wetland+® at the sites. The methodology is to build pilot prototypes for the technology and a progenitor of all subsequent installations. After building and commissioning the wetland at the Hajek site, long-term monitoring began, and based on this, system modifications were performed where necessary. All the technology parts of the Wetland+® system were assessed regarding their particular contribution to the overall performance. The results were generalised for similar installations in variable environmental conditions. A methodology was successful even in case of unexpected problems in the termination of the work by a subcontractor, and the objectives were achieved. Lessons learned include that the work where beneficiaries are not experts has to be subcontracted. This action ran for most of the project period (representing not only construction but also system-wide optimization and supporting activities) and represented a total of 118 MM, or 39% of the total MM of the project. This is by far the largest share, which corresponds to the project objective of building and optimizing the Wetland+ system. The share of MMs is lower than planned (43%) even though the optimization of the system required some activities.

(C) Environmental and socio-economic monitoring is essential to the project's successful implementation. Environmental (and performance monitoring) influenced the system modifications significantly. Lessons learned are that even though the system was tested on the site as a small pilot installation, the upscaling can bring difficulties and problems that must be solved. So, the maximal time for a system operation in a test regime is recommended, and financial sources for intensive and complete monitoring and technology modification must be planned. The socio-economic impact is an essential part of the system assessment. Lessons learned is to make an initial comparison the technology with other potential technologies already in the project preparation phase (Technical and economic studies), which helps in the final assessment. Action C ran throughout the project and represented a total of 81 MMs, which is 27% of the total MMs of the project. This proportion was higher than planned (23%). This was due to the higher intensity of sampling and analysis during the system optimization phase. This was necessary to find tools to increase the efficiency of HCH degradation.

(D) Public awareness and dissemination of results set an evolutive methodology, which we have named the Replication Conveyor Belt. A list of candidate sites was provided, and the sites were assessed. The desk study for the selected sites provided a feasibility study, an estimation of a budget for laboratory tests, a budget and space needed for a pilot scale installation, and a provisional budget for a pilot scale installation. The lesson learnt is that a communication & dissemination plan should be prepared at the beginning of the project, updated during the project duration and the final version at the end of the project for the after-life activities. Action D ran throughout the project and represented a total of 48 MMs, or 16% of the total MMs of the project. This proportion was planned.

(E) Project management comprised the activity for smooth implementation of the project and the project After-LIFE plan for the sustainability phase of the project. One project amendment was issued, which helped P1 installation and maintenance. The methodology involved setting the different boards and their responsibilities, dividing the work between beneficiaries, regularly checking the results, and solving incoming problems. The action met the objectives and was successful. Lessons learned from the management include that the project coordinator must regularly and sincerely monitor tasks for which partners are responsible. The beneficiaries tend to transfer the responsibility to the coordinator. Action E ran throughout the project and represented a total of 38 MMs, or 13% of the total MMs of the project. This proportion was planned.

Achievement of the project objectives:

The project results are immediately visible on both sites where the Wetland+® systems were built. The results in replication on other sites will hopefully be visible within the sustainability phase of the project. The difficulties are in ensuring finances for replication because the potential clients have problems financing such activities.

- Objective "to install a large-scale pilot prototype "P1" at Hajek (CZ), exhibit system performance at a commercially relevant scale and provide an exemplar to support replication" was achieved by commissioning the "P1" remedial system at Hajek. For replication of the Wetland+® system, the installation is monitored, and its performance is adjusted.
- Objective "to set a field pilot deployment prototype "P2" at Jaworzno (PL), a site which differs by the contamination context, hydrogeological conditions, microbial communities, and local resources such as sorbent materials" was performed by adapting the system to the local conditions, system design, arrangement of all necessary permits, and start of the construction.
- Objective "to establish a specific replication pathway for the technology to other sites, to test an innovation in the performance of green monitoring and analysis" was performed by selection of the potential sites to put on the Replication Conveyor Belt. The list of candidate sites was provided, and sites were assessed.
- Objective "to develop process control strategies for remote locations by use of renewable energy and resources" was prepared by designing the solar cells system at the Jaworzno site, which was installed after P2 commissioning.
- Objective "to ensure project dissemination by involvement and communication with different audiences and interest groups on a European and global scale" was performed by presentation of the project to different stakeholder groups, conferences and events, special sections on two conferences organized by the team, printing of scientific papers and articles to non-scientific journals, information in national and local media.

Policy impact:

No action related to change EU or national legislation was planned. Implementing the technology in other locations does not require any legislation changes. The main barrier to replicating the technology is ensuring financial sources for potential replicants.

Detailed description of the project actions, their expected and achieved results and their evaluations are in the following table:

Action	Foreseen in the revised proposal	Achieved	Evaluation
A.1 Preparatory of Hajek construction	Objectives: Obtain all necessary permits for the implementation action and ensure the conditions for the construction. Expected results: Obtaining the Building permit and tendering of the constructor	All permits were obtained in time, and the construction company was selected based on the tender.	DA1 – summarizes all legal documents necessary for the system building at Hajek site. The report also describes the updated situation at the site.
A.2 Preparatory of Jaworzno construction	Objectives: The gathering and structuring of the existing information and obtaining the permits necessary for the implementation. Expected results: Obtaining the Building permit and tendering of the constructor	All permits were obtained and subcontractor selected with a delay. The deadline was postponed due to COVID-19.	DA2 - summarizes all legal documents necessary for the system building at Jaworzno site. The report also describes the system modification for the site.
B.1 Installation of P1 at the Hajek site	Objectives: Installation of Wetland+® P1 at Hajek site. Expected results: Commissioning P1 system at Hajek and starting the testing period	The system was completed and launched on 15.10.2021.	DB1 -summarizes the Wetland+® system at Hajek and provides the results of the on-site tests.
B.2 P1 Operation and Validation	Objectives: (SO1) The proposed Wetland+® setup is tested as a large-scale pilot prototype Expected results: Full operation of the system with an optimized efficiency for HCH removal	Few system modifications were made to improve the system's efficiency.	DB7- summarizes the first operation stage, DB8- summarizes maintenance plan for long-term performance, DB9- summarized the overall system performance , DC6 – summarizes the technology efficiency.
B.3 Design and Installation of P2 at Jaworzno	Objectives: (SO2) The proposed Wetland+® setup is tested for the site-specific replication of the technology on the other site Expected results: Commissioning P2 system at Jaworzno and starting the testing period	The system was completed on 27. 12. 2022. The deadline was postponed due to the subcontractor's failure and the new tender process.	DB4 - summarizes the Wetland+® system at Jaworzno and provides the results of the tests on site.

B.4 P2 Operation and Validation	Objectives: Testing the Wetland+® system at the second pilot site, including (SO5) using of renewable energy for remote locations Expected results: To find the optimal operation of the system for HCH removal	Few system regimes were tested on the system to get its efficiency.	DB6 - summarizes the first operation stage, DB10- summarizes system performance, DB13- summarizes maintenance plan for long-term performance, DC6 – summarizes the technology efficiency.
B.5 Prototype Implementation Assessment	Objectives: To assess Wetland+® technology Expected results: Technology Guide for the following system applications	The optimal and reliable conditions for the Wetland+® technology are provided.	DB11 – it is a technology guide summarizing all essential modules of the Wetland+® system and its performance for HCH treatment
B.6 Replication and Business Planning	Objectives: (SO3) A specific project replication process and candidate sites have been actively canvassed. Expected results: A business model to service replication needs.	The global benefit study for the technology Wetland+® was completed, and pros and cons were identified.	DB2 selects potential candidate sites, DB3 – starts the replication process DB5 – service package for clients of Wetland +® DB12 – replication plan with selected sites, DB14 – Business plan.
C.1 Monitoring of Environmental Impact	Objectives: To monitor the impact of the technology; and (SO4) green monitoring via tree biomass. Expected results: Significant improvement of HCH-influenced environment at P1 site	The removal efficiency was 83.9%, 96.4% and 84.5% for HCH, ClB and ClPh, respectively.	DC2 – checks the efficiency of P1, DC4 – checking the KPIs in the middle of the project, DC6 – demonstrate the efficiency, DC8 – summarized the meeting of KPIs.
C.2 Monitoring of the Social Economic Impact	Objectives: To demonstrate that the technology is environmentally, economically, and socially acceptable. Expected results: Positive assessment of the social economic impact and comparison with alternative technologies	Comparison with WWTP and no-action scenarios ranked Wetland+® best in sustainability.	DC1, DC3, DC7 – report the social economic impact of the technology on both sites (baseline, interim and final). DC5 – evaluation of LCA for Wetland+® technology.
D.1 Dissemination Planning and Execution	Objectives: (SO6) Communication and dissemination ensured the result reached different audiences and interest	List of conferences and events attended list of scientific	DD1 – project web sites DD2 – networking strategy

	groups on an EU and global scale. Expected results: The dissemination and communication plan to increase the awareness of LIFEPOPWAT among scientific and potential end-users.	papers submitted, special sections on conferences, contacts with potential clients.	DD3 – List of potential replication sites DD4, DD7 – reports on communication and dissemination DD5 – recommendation notes for Wetland+® DD6 – ranking of potential sites DD8 – Layman´s report
E.1 Project Management (PM)	Objectives: Management of the project, including After-Life plan Expected results: All documents and actions needed for smooth project interpretations	Nomination of all project boards, project reporting, After-LIFE plan for sustainability period.	DE1 – summarizes green procurement for the project course DE2, DE4 – After-LIFE plan (midterm and final) DE3 – Midterm report DE5 – this report

EU Added value was matched against ones foreseen in the proposal. As was expected, the project results, including environmental effects as well as social and economic effects, were compared to a potential baseline (no action or no intervention baseline) and a conventional removal action, WWTP. The breadth of sustainability effects is broad and includes effects such as landscape or societal impacts that are not capable of quantitative evaluation, at least to the satisfaction of all likely stakeholders. Our approach was to combine quantified estimated comparisons against baseline for (1) risk mitigation in terms of flux of HCH to receiving waters as a measurable surrogate; (2) resource and energy intensities in terms of estimated aggregate tonnages, and aggregate economic value, which represents scarcity of resources; (3) carbon intensity in terms of estimated carbon balance; (4) aggregate tonnage and estimated cost of disposal as a surrogate for level of hazard; (5) aggregate volume of treated water.

The quantifications were supplemented by a qualitative sustainability appraisal of LIFEPOPWAT against the baseline for the two sites, including a range of local stakeholder perspectives described in ISO18504:2017 on Sustainable remediation. Both alternative scenarios (no action and WWTP) were essentially hypothetical. A no-intervention baseline is not acceptable to local authorities. A baseline WWTP scenario cannot be applied in practice because of cost, remote location, complexity and conflict of interest.

Sustainable development: Constructed wetlands are an environmentally friendly solution to pesticide leaks. However, the installation does not solve the main problem: the former burying thousands of tons of pesticide waste into the unsecured dumps. Pesticide leakage into groundwater and watercourses will last centuries if robust remediation action is not conducted in the dumps' source zones. However, wetland installation brings purity to treated water before such massive and expensive actions are taken. This is a significant benefit of the LIFEPOPWAT implementation, especially important if current climatic trends towards warmer and drier EU summers continue. Wetland installation also eliminates the risk of toxic effects for forest animals, fish and crustaceans living in watercourses near both dumps. As pilot examples, wetlands at Hajek and Jaworzno will hopefully be followed by further sites with similar problems throughout EU, bringing pure water to other watercourses.

Synergies, multipurpose and integration: Priority "Water, including the marine environment" has been selected for LIFEPOPWAT as the most suitable. Therefore, project impacts are closely connected with the EU Energy, climate change and environment policy (e.g. safer use of chemicals, limiting exposure to toxic chemicals, climatic change mitigation, landscape protective effect, biodiversity protective effect, renewable energy sources or circular economy). However, the project has many added values in other EU policies, e.g. in food, farming, fisheries (consumer protective effect - sea and river fishing, aquacultures, health and safety), EU regional and urban development (environment and resource efficiency, health, tourism) or the law (international agreements, regulations, legislation, etc.). The use of engineered wetlands is in line with the objectives of Water Framework Directive on restoration of aquatic ecosystems.

The project seeks to meet the following objectives of the 2000/60/EC European Parliament and Council and the Stockholm Convention on Persistent Organic Pollutants (2001):

- the project focused on measures leading to the removal of priority substances from groundwater, surface water and wastewater pollution, with a focus on the reduction of water contamination by persistent organic pollutants (biocidal products);
- the project contributed to the rapid reduction of emissions of hazardous compounds into waters and to the protection of waters and terrestrial ecosystems;
- the project itself and the developed technology allowed for economically sustainable and effective solutions leading to the reduction and consequent elimination of water pollution caused by old environmental liabilities that threaten water quality;
- the implementation of the proposed solution at the Jaworzno site led to the reduction of POP emissions to the economically significant Przemsza River and subsequently to the Vistula River and the Baltic Sea, which the Vistula enters. Verifying the functionality of the Jaworzno technology can lead to further expansion of the application of the proposed technology at the site and ultimately to the final elimination of damage to the Wąwolnica and Przemsza rivers;
- the application of the technology at the Hájek site led to the reduction of HCH substances in the outflow from the site and inflow to ecosystems, including a Natura 2000 area;
- the outputs of the project contribute to the implementation of Directive 2013/39/EU of the European Parliament and of the Council of the European Union of 12 August 2013, supplementing Directive 2000/60/EC and 2008/105/EC concerning water policy priorities and the Stockholm Convention on Persistent Organic Pollutants;

6.4 Analysis of benefits

1. Environmental benefits:

- Direct/quantitative environmental benefits: The benefits specified in the project proposal and set as the KPI are the means of mitigating risks to water from the HCH-contaminated sites, by using the Wetland+® technology. The monitoring data determined over two years of operation showed a significant reduction in HCH, ClB, and ClPh in the outflowing water. The increase in removal efficiency continues due to growing of wetland plants and system improving. In the period of system operation (27 months), 131,000 m^3 water was treated, and about 12.8 kg of HCH, 68.5 kg of ClB and 1.2 kg of ClPh were removed.
- Decreasing the load of contaminants in the water flowing through Ostrovsky creek to a system of lakes will increase public amenities for fishing and hunting, improve the value of the land due to the removal of toxic odours, create potential for site renewable tourist projects, habitat, and conservation benefits, etc.
- Applying alternative treatment technology, e.g., WWTP, can bring about similar environmental effects. However, such technology needs chemicals and sorbents for

contaminant elimination, electric energy and moreover produces toxic wastes, which have to be stored. Such process needs a continuous operation, personal staff and delivery. All these activities bring loads to the environment, safety and society.

- Qualitative environmental benefits: Installed technology Wetland+® is sustainable in the long-term horizon. Based on maintenance management plans (DB8 and DB13), the installation can operate with appropriate management for decades. Similar installations can solve problems in other locations in EU and outside. The P2 installation at Jaworzno also proved that the processes in the Wetland+® technology can successfully treat other POP compounds. After modification, the technology can also be successfully applied to treat "new" contaminants in water (like pharmaceuticals, antibiotics, and hormones).

2. Economic benefits:

- The Wetland+® scored over WWTP in the categories of direct and indirect economic costs and benefits and equalled in the induced economic costs and benefits. Wetland+® is cheaper over the long term than WWTP.
- Regarding indirect economic benefit, Wetland+® has a more significant potential benefit for surrounding property value as it removes the staining in the stream and is not as intrusive as a WWTP. Wetland+® may be closer to the sustainability aspirations of DIA to show that the organisations involved share a goal of low input and sustainable solutions. Either solution will improve the reputation of DIA, whereas no action damages its reputation. A local source of income is for hunters who may be less willing to pay to come into an area with a stream with visible contamination. Both treatments protect downstream fisheries. There are no additional local tax-raising benefits for any of the options.
- Induced economic costs and benefits: Improvement of the stream, either by Wetland+® or WWTP, improves the attractiveness of the area downstream of treatment for a broader range of land use opportunities. Additionally, Wetland+® offers to strengthen innovation and skills and provides a platform for replication elsewhere.
- Conventional WWTP likely has greater local job creation potential (e.g., for a technician). Wetland+® creates local maintenance needs, potentially for sheltered employment (e.g., if the maintenance contract is given to a local NGO, charity, or wildlife trust). WWTP is not likely to change skill levels at DIA, whereas Wetland+® introduces new know-how. Wetland+® offers the broadest and most attractive range of opportunities for school visits.

3. Social benefits:

- The Socio part of the survey showed better scoring of the Wetland+® system over WWTP in three categories (Human health and safety, Neighbourhoods and locality, Communities and community involvement), while in Uncertainty and evidence the WWTP scored better.
- Human health and safety: Both treatment solutions meet the necessary surface water treatment criteria, reducing risks. Risks to site workers are likely higher for the WWTP as it is an operating process plant. Both treatments improve the amenity value of the local area, making it more attractive for physical recreation. Wetland+® acts as a destination to encourage people outside.
- Neighbourhoods and locality: Given the remoteness of the location, there are no likely neighbourhood concerns over effects from dust, light, noise, odour, vibrations and traffic. There is no local built environment or archaeological consequence. A remote WWTP is potentially an attractive destination for thieves and vandals in a way that Wetland+® is not.
- Communities and community involvement: Both treatments improve the river's amenity downstream, benefiting local communities. Wetland+® offering a higher linkage to sustainable development policy goals.

- The robustness and rigour of the information for option design provided are higher for WWTP because it is so well established, it has more straightforward process control at present, and its outcomes are more readily validated. So, the Wetland+® technology showed higher uncertainty.

4. Replicability, transferability, and cooperation:

- Wetland+® technology has tremendous potential for replication at other sites with similar types of contamination. The technology is fully competitive with standard solutions. The LCA analysis also confirmed a significantly lower burden on the environment, humans and nature than WWTP.
- A limiting factor is the generally scarce resources to solve environmental problems similar to those in Hajek or Jaworzno. Owners of contaminated sites are often not sufficiently pressured by the relevant state supervisory authority to remedy ecological damage. A frequent argument is that pressure to clean up the runoff would disproportionately burden the owner's economy and make the operation uncompetitive.
- The most accessible sources of funding are environmentally based national or EU programmes. However, these are often won by solutions that are proven but uneconomic and unnecessarily complicated (construction of WWTPs). They are also costly to operate, which can lead to premature closure.
- In some cases, such as Jaworzno itself, the pressure from the local population is low, and the fear of losing their jobs due to the closure of the contamination source is greater than the environmental pressure.
- Beneficiaries have made extensive presentations of the technology at many conferences and other events (often from other sources) with the aim of changing awareness in the scientific and non-scientific community concerning green, environmentally friendly water treatment solutions.
- Therefore, the team believes that the project's likelihood of replication is high. Of course, there is also a thread here for policy representatives.
- A roadmap for replication is in place, and the individual steps have been costed.
- The project team completed the C2M checklist twice, as recommended, once before the midterm report and once at the end of the project. During the project, the C2M team organised a discussion on the applicability of the project.

5. Best Practice lessons:

The entire project methodology was set up correctly at the beginning and led to the successful achievement of the project objectives. From our experience in project management, a few practice lessons were learnt:

- The communication & dissemination plan should be prepared at the beginning, updated during the project duration and the final version at the end of the project for the after-life activities. During the project duration, changes can directly influence the dissemination activities.
- Even though the risk analysis is prepared at the preparation phase of the project proposal and again at the start of the project, there are always unpredictable risks that could not be expected. In our case, it was the COVID situation. A recommendation is that unexpected problems can prolong individual actions, so it is necessary to plan the subsequent actions with sufficient time to cover such issues. Lessons learned include that the work where beneficiaries are not experts should be subcontracted.
- Another lesson learned is that even if the system was tested on a small scale before the project, the upscaling can bring difficulties and problems that need solving. So, it is recommended to maximise the time for a system operation in a test regime and reserve

sufficient financial sources for intensive and complete monitoring as well as for technology modification of the system in case of needs.

- Lessons learned from the management include that the project coordinator must regularly and sincerely monitor tasks for which partners are responsible. The beneficiaries tend to transfer the responsibility to the coordinator.

6. Innovation and demonstration value:

- Projects of this type that address pan-European (or global) issues should be managed internationally. The added value is the use of international experience from different workplaces, which is impossible at a national level, especially in the case of smaller countries. The second added value is the dissemination of results again at an international level, where, e.g., a HCH mega site is in every country, and therefore, the knowledge transfer has to be global. Pilot validations at one or two sites in two countries allow replication of the technology in other countries. The problem is that for replication, it is necessary to secure resources which may already be national.

7. Policy implications:

- Priority "Water, including the marine environment" has been selected for LIFEPOPWAT as the most suitable. Therefore, project impacts are closely connected with the EU Energy, climate change and environment policy (e.g. safer use of chemicals, limiting exposure to toxic chemicals, climatic change mitigation, landscape protective effect, biodiversity protective effect, renewable energy sources or circular economy). However, the project has many added values in other EU policies, e.g. in food, farming, fisheries (consumer protective effect - sea and river fishing, aquacultures, health and safety), EU regional and urban development (environment and resource efficiency, health, tourism) or law (international agreements, regulations, legislation, etc.). The use of engineered wetlands aligns with the objectives of Water Framework Directive on the restoration of aquatic ecosystems.
- A service package that the consortium offers to clients interested in considering Wetland+®. This includes elements such as standardised templates for initial feasibility assessment, reproducible and systematic procedures for pilot scale prototype testing and upscaling, mechanisms for cost projection, “hooks” to key aspects of EU environmental regulation policy and a basis for developing a value proposition and investment case for Public and Private investors. The task also considers commercial models for accelerating market uptake and replication (e.g. agency/ brokerage pathways, franchising, etc). The partners have expressed willingness to collaborate on some form of joint activities. The exact mode is not decided, e.g. spin-out company, formal joint venture, collaboration agreements, etc. So, we now describe it as a “Joint Venture Partnership”. Determining its nature and constitution will be done in time the activity will be actual.

7. Key Project-level Indicators

The project set at the beginning Key Performance Indicators. These are not only of environmental, but also societal and economic as well as general KPIs about the project. The key environmental KPIs are indicators confirming the removal of HCH and other contaminats from drainage water flowing on both sites.

The indicators were set as initial values at the beginning of the project (before any project actions), values at the end of the project, and values three years after the end of the project. Some of the indicators were set separately for the two territorial extents (Czech R. and Poland) and specific water bodies (Ohře River short of the reservoir Nechranice abandonment, CZ) and (Przemsza after confluence with Biala Przemsza). Altogether, three Specific contexts were defined:

- HCH removal at CZ (related to the P1 at Hajek site, in Ohře basin) [CZ/CZ0/CZ04/CZ041]
- HCH removal at Poland (related to the P2 at Jaworznosite, in Przemsza basin) [PL/PL2/PL22/PL22B]
- The project impacts both regions (related to site non-specific KPIs).

The KPIs are of the following selections:

- Project settings:
    - Area of environmental/climate implementation actions (1.5) [for both sites]
    - Persons who may have been influenced via dissemination or awareness raising project-actions (1.6) [site not-specific]
- Environmental outputs
    - Aquatic extent affected by the pressure or risk addressed (2.2) [related to CZ only; in PL there is no aquatic extent influenced by the Wetland+® technology]
    - Point source pollution (2.3.6) [specifically defined for both sites]
    - Nature and biodiversity - Ecosystem assessment (7.1) [related to CZ only; in PL there is no ecosystem assessment]
- Societal outputs
    - Involvement of non-governmental organisations (NGOs) and other stakeholders in project activities – private for profit (10.2) [site not-specific]
    - Involvement of non-governmental organisations (NGOs) and other stakeholders in project activities – public bodies (10.2) [site not-specific]
    - Website (11.1) [site not-specific]
    - Number of articles in print media (e.g., newspaper and magazine articles) (11.2) [site not-specific]
    - Members of interest groups/lobby organisations influenced by the project (12.1) [site not-specific]
    - New jobs related to the project (13.) [related to CZ only]
- Economic outputs
    - Running cost/operating costs during the project and expected in case of continuation/replication/transfer after the project period (14.1) [site not-specific]
    - Revenue expected in case of continuation/ replication/transfer after the project ends (14.2.3) [site not-specific]
    - Beneficiary own contribution in the future fundings (14.3) [site not-specific]
    - Entry into new entities/projects (14.4.1) [related to PL site]
    - Entry into new geographic areas (14.4.3) [specific for selected countries]

Indicator 1.5 Project area (Area of environmental/climate implementation actions (e.g. development, testing, demonstration, application of best practices/innovations)		
Hajek site: Start value: 0	End value: 0.5 ha	Area of installed passive technology. About 1/2 is aerobic wetland, 1/2 other units (oxidation, reduction, sorption)
Comments: In September of 2021, a projected Wetland+® system of .5 ha has been created. The system has remediation/sorption parts and a part of a constructed aerobic wetland planted with appropriate wetland plants. The plants grew over the next period, and the wetland´s environmental functions increased. From that time till the project's end, the system runs in the testing regime. At the end of the project (27. 12. 2023), the P1 prototype was changed to operational mode (DC8).		
Jaworzno site: Start value: 0	End value: 0.2 ha	Overall area of installed technology, the constructed wetland has two parts (730 m^2), the rest is the tubing, inflow and outflow, and maintenance area.
Comments: In December 2022, a projected Wetland+® system was constructed on an area of 0.2 ha. The system is composed of containers and two wetland parts of 150 and 580 m^2. The system is much smaller than the Hajek site and has another objective – to test the system in different regions with different water and contaminant compositions. A solar source supplemented the system to test the technology at remote locations without electricity. The system was also designed not to improve any contaminated areas.		
Indicator 1.6 Humans (to be) influenced by the project		
Start value: 0	End value: 2000	Persons who may have been influenced via dissemination or awareness raising project-actions
Comment: During the project, the project results were presented at over 50 events (conferences, meetings, seminars, see the list below). It is difficult to estimate exact numbers of participants on these events. The total number of participants in these meetings is estimated to be 6,000. The number 2000 was chosen as 1/3 of the participants, which is on the lowest level of estimate. Moreover, the results were presented for PhD students (the estimated number is 55). The site P1 is regularly visited by tourists (cycling track). The estimate is around 30 people monthly (during the summer months). The project was presented also on national TV and radio and in newspapers (separate indicator). The project websites are also a separate indicator. The list of the conferences with estimated number of participants. At three conferences, there was organised a special session about the project.		

Date	English title	Activity	Nr. (cca)
Conferences and workshops and meetings and visits			
16.06. 2020	LINDANET workshop	LIFEPOPWAT presentation	20
08.07. 2020	Press conference in Hroznetin	LIFEPOPWAT presentation - discussion with journalists	40
07.10. 2020	EcoPOLE conference	LIFEPOPWAT presentation	50
24.11. 2020	LINDANET conference	LIFEPOPWAT presentation	20

26.1.2021	15th DWF Danish Water Forum, 2021	LIFEPOPWAT presentation	150
01.04.2021	Pan-American Network of Wetland Systems (UFSC, Brasil)	LIFEPOPWAT presentation	150
16.09.2021	9th International Symposium on wetland dynamics and polution control, 2021	LIFEPOPWAT workshop, presentation + **special session**	200
21.10.2021	NANOCON conference	LIFEPOPWAT presentation - distribution of LIFEPOPWAT leaflets	350
04.11.2021	17th Workshop on circular economy and dumps-Zittau/Liberec	LIFEPOPWAT presentation	30
16.11.2021	Workshop - HCH in EU	LIFEPOPWAT presentation	35
23.11.2021	Meeting of the Economy and Environment Committee of the Jaworzno City Council	LIFEPOPWAT presentation	9
2022	Pan-American wetland conference, Brazil	LIFEPOPWAT presentation	200
01.02.2022	Workshop: Technological University of Pereira	LIFEPOPWAT presentation	40
02.02.2022	Workshop INVEMAR (Colombia)	LIFEPOPWAT presentation	25
04.04.2022	2nd International Conferences on Nanotechnology and Chemistry	LIFEPOPWAT presentation	80
20.04.2022	16th DWF Water Research Conference, 2022	LIFEPOPWAT presentation	150
17.05.2022	17th International Conference on Wetland Systems for Water Pollution Control - Lyon	LIFEPOPWAT presentation, **special session** - https://iwa-network.org/events/17th-international-conference-on-wetland-systems-for-water-pollution-control/	200
21.05.2022	12th lnternational Conference on Remediation of Chlorinated and Recalcitrant-Compounds (Battelle 2022)	LIFEPOPWAT presentation	80
13.06.2022	International conference TNC2022	LIFEPOPWAT presentation - https://tnc22.geant.org/posters/#c225	120
09.07.2022	Visit of EU journalists	LIFEPOPWAT presentation: https://cxi.tul.cz/novinky/201/detail	50
21.07.2022	CzWA - seminar	LIFEPOPWAT presentation - https://www.czwa.cz/program-CZ545	35
01.09.2022	10th Int. Symposium on wetland dynamics and polution control	LIFEPOPWAT presentation	150
08.09.2022	Meeting with stakeholders and Hajek site visit - LIFE "30" anniversary	meeting with stakeholders + Hajek site visit	40

11.09. 2022	IWA World Water Congress & Exhibition, September 2022 – Copenhagen	LIFEPOPWAT presentation - https://iwa-network.org/events/iwa-world-water-congress-exhibition-2022-copenhagen/	150
28.09. 2022	REMEDy 2022 Hybrid-Conference for Contaminated Sites	LIFEPOPWAT presentation - https://www.remedysummit.com/	20
30.09. 2022	Night of Scientists 2022	LIFEPOPWAT presentation: https://tuni.tul.cz/a/tul-prichystala-noc-behem-niz-ozily-vsechny-smysly-142296.html, https://liberecky.denik.cz/zpravy_region/noc-vedcu-univerzita-tul-liberec-20221001.html	400
06.10. 2022	Celebrating 10 years of "CXI"	LIFEPOPWAT presentation: https://liberec.rozhlas.cz/vyzkumne-centrum-liberecke-technicke-univerzity-slavi-10-let-od-otevreni-sve-8843109, https://cxi.tul.cz/novinky/220/detail	200
03.11. 2022	Minister Langšádlová visited the Liberec Region	https://cxi.tul.cz/en/event/230/detail	10
07.11. 2022	17th Int. Conference on Wetland Systems for Water Pollution Control	LIFEPOPWAT presentation	150
19.10. 2022	EcoPOLE conference	LIFEPOPWAT presentation	50
19.10. 2022	Business mission to Ankara.	LIFEPOPWAT presentation	5
09.11. 2022	18th Workshop on circular economy and dumps-Zittau/Liberec	LIFEPOPWAT presentation	30
22.11. 2022	Meeting of the Economy and Environment Committee of the Jaworzno City Council	LIFEPOPWAT presentation	9
22.11. 2022	6th International Conference on Nanomaterials ICNB2022	LIFEPOPWAT presentation	70
2023	Pan-American wetland conference, Colombia	LIFEPOPWAT presentation	150
15.01. 2023	13th IWA International Conference on Water Reclamation and Reuse, Chennai, India	LIFEPOPWAT presentation - https://iwareuse2023.com/	150
08.02. 2023	17th DWF Water Research Conference, 2023	LIFEPOPWAT presentation	150
21.02. 2023	14th International HCH and Pesticides Forum in Zaragoza	LIFEPOPWAT presentation + **special session**	80

21.03. 2023	IWA - Water Loss Conference 2023 in Port of Spain	LIFEPOPWAT presentation (paper + poster)	80
30.04. 2023	SETAC Europe 33rd Annual Meeting	LIFEPOPWAT presentation	60
29.05. 2023	LET2023 – The 18th IWA Leading Edge Conference, Daengu, South Korea	https://iwa-network.org/events/let-2023/	50
14.06. 2023	VI Pan American Conference on Wetland Systems for the Treatment and Improvement of Water Quality, Popayán 2023	LIFEPOPWAT presentation - https://www.unicauca.edu.co/portaleningles/events/vi-pan-american-conference-wetland-systems-treatment-and-improvement-water-quality-popayan	120
22.07. 2023	H.E. Phasporn Sangasubana (Ambassador of the Kingdom of Thailand to the Czech Republic) visited Hajek site	https://cxi.tul.cz/lifepopwat/dissemination-activities-and-pr	3
10.09. 2023	10th International Symposium On Wetland Pollutant Dynamics and Control	LIFEPOPWAT presentation - https://wetpol.org/	250
11.09. 2023	AquaConSoil 2023	LIFEPOPWAT presentation - https://www.aquaconsoil.com/	450
18.09. 2023	ANS2023 - 8th International Scientific Conference Applied Natural Sciences	LIFEPOPWAT presentation - https://ans2023.ucm.sk/	50
04.10. 2023	CWA 2023, England	LIFEPOPWAT presentation - https://constructedwetland.co.uk/events/conference/2023	120
06.10. 2023	Night of Scientists 2023	LIFEPOPWAT presentation: https://cxi.tul.cz/en/event/307/detail	400
02.11. 2023	Sustainable remediation introduced, latest from SuRF-UK and a case study	Global Nature Based Solutions to Mine Tailing Waste Water 2023 - Kazakhstan online - active participation - LIFEPOPWAT presentation	40
02.11. 2023	Sustainable remediation introduced, latest from SuRF-UK and a case study	SURF-JAPAN, AIST, Tokyo - active participation - LIFEPOPWAT presentation	50
13.11. 2023	RemPlex 2023 - Global Summit on Environmental Remediation	online LIFEPOPWAT presentation - https://www.pnnl.gov/projects/remplex/2023-summit	110
28.11. 2023	Meeting of the Economy and Environment Committee of the Jaworzno City Council	LIFEPOPWAT presentation	9
2021-2023	5 meetings in India (IWA, IWWA, AMU)	LIFEPOPWAT presentation	500
Teaching acitivities/meetings - PhD. courses			

2022, 2023	Colombia, in Pereira (UTP) and Santa Marta (INVEMAR)	10
2022, 2023	CADI University in Morocco	15
2021	Portugal CIMAR	10
2020-23	Universidad Católica del Maule, Centro de humedales de Valdivia, Universidad de Playa Ancha, Universidad Austral de Chile and Universidad Adolfo Ibáñez (Chile)	20

Indicator 2.2 Aquatic extent affected by the pressure or risk addressed

Start value: 1 km	End value: 0 km	The Ostrovsky creek, as HCH and CB polluted an outflow from the contaminated site. The creek flows through a game area and contaminates the environment.

Comments: This indicator is related to the P1 site at Hajek only because its primary objective was to treat contaminated water from the site. The P2 site has a testing purpose and does not directly affect aquatic extent. Three environmental monitorings indicate the significant improvement of Ostrovsky Creek's (and therefore all downstream water bodies') water quality. The first indicator is HCH mass discharge into the creek, when after the Wetland+® system commissioning, such discharge decreased from about 23-25 g/day to 0.3 – 11.3 g/day (the highest number was detected during the extreme water flow; for a regular flow, the highest value is below 3 g/day), marking an approximate 51% to 99% decrease. Overall, the discharge is about an order of magnitude lower than before the system installation.
The permissible water pollution is determined according to the Government Regulation 401/2015 Coll. on indicators and values of permissible pollution of surface water and wastewater, the requirements for permits to discharge wastewater into surface water and sewers and on sensitive areas. The regulation sets threshold levels for the discharge of pollutants contained in wastewater, below which it is not necessary to require daily 24-hour monitoring. The values apply in particular to the monitoring of leachate from tailings ponds, landfills or contaminated soils and other environmental loads. For the sum of the hazardous isomers of HCH the value is 3 kg/year. ε-HCH is not included in this sum because of its unproven carcinogenicity. This isomer is also not prohibited by the Stockholm Convention. Based on this regulation, in the inflow to Horní Štít pond (outflow from Ostrovsky Creek), there is an average 87% decrease in the concentration (from 9.9 µg/l to 1.3 µg/l). The residual annual discharge to Horni Stit is 137 g of considered HCH isomers (without ε-HCH).
This trend is expected to continue because sediments in the creek are still contaminated, and time is needed to wash them with water of significantly lower HCH (and other contaminants) concentration. The third indicator is the significant increase in biodiversity expressed by the number of phytobenthos (Diatoms) species, commonly used biomarkers of an aquatic environment. This is in details described in the 7.1 Ecosystem Assessment KPI.

Indicator 2.3.6 Point source pollution -Hajek

Start value (/year): Alpha-HCH= 570 g Beta-HCH= 82 g Gamma-HCH= 410 g Delta-HCH= 6400 g Epsilon-HCH=650 g	End value (g/year): Alpha-HCH= 17 g Beta-HCH= 46 g Gamma-HCH= 8 g Delta-HCH= 65 g Epsilon-HCH= 270 g	Removal of the contaminant by the installed technology. The efficiency is expected to be improved slightly in the next period.

<table>
<tr><td>Chlorobenzene= 32 kg
Chlorophenols= 890 g
Iron compounds= 1300 kg
Manganese= 150 kg</td><td>Chlorobenzene=2 kg
Chlorophenol= 105 g
Iron compounds= 25 kg
Manganese= 30 kg</td><td></td></tr>
<tr><td colspan="3">Comments: The inflow water from the Hajek quarry spoil heap to the Wetland+® system is contaminated by a mixture of organics: HCH isomers, ClB, and ClPh, and inorganics: Fe and Mn. During the 809 days of the system operation, the P1 prototype eliminated 12.8 kg of HCH, 68.5 kg of ClB and 1.2 kg of ClPh. In the case of HCH, the efficiency of the individual HCH isomer removal is different; therefore, the ratios among them change. While in the inflow, δ-HCH dominates, ε-HCH is the most abundant in the outflow. The residual discharges to Ostrovsky Creek were: α-HCH of 17 g, β-HCH of 46 g, γ-HCH of 8.2 g, δ-HCH of 65 g and ε-HCH of 270 g. In the following period, the system's efficiency will increase due to the growth of the wetland plants, and the outflow concentrations (and annual amounts) will be even lower. Inorganic compounds are represented by high concentrations of dissolved Fe (average 25.8 mg/l) and Mn (3.0 mg/l). The Wetland+® system reduces these concentrations to about 0.5 mg/l for each. It removed about 2 tons of Fe and 212 kg of Mn.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Indicator 2.3.6 Point source pollution –Jaworzno</td></tr>
<tr><td>Start value (/year):
Alpha-HCH= 9 g
Beta-HCH= 3.4 g
Gamma-HCH= 7.8 g
Delta-HCH= 8 g
Epsilon-HCH= 2 g
Chlorobenzene= 156 g
Chlorophenols= 5.4 g</td><td>End value (g/year):
Alpha-HCH= 0.9 g
Beta-HCH= 0.1 g
Gamma-HCH= 0.1 g
Delta-HCH= 1.3 g
Epsilon-HCH= 0.5 g
Chlorobenzene= 62 g
Chlorophenols= 3.5 g</td><td>The chlorobenzenes and HCH were eliminated from the outflow by the Wetland+® system. P2 in Jaworzno is a pilot system on a small scale.</td></tr>
<tr><td colspan="3">Comments: The trial operation of the P2 prototype lasted only nine months (from March 2023 till the end of November 2023). The prototype operation was divided into a few stages, where various HCH concentrations and flow rates were tested. The efficiency of HCH removal until May 2023 was low due to varying HCH concentrations at the inlet and unstable flow. The efficiency gradually increased, and from June to the end of July 2023, a very high HCH removal efficiency (83% to 97%) was observed. In the second half of the test, when the flow rate increased (i.e., residence time decreased), the HCH removal efficiency decreased and varied between 46% and 81%. In 2023, the system treated about 1800 m^3 of contaminated water, and the following mass of pollutants was eliminated: 27.3 g of HCH, 1.9 g of ClPh, and 94 g of ClB.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Indicator 7.1 Ecosystem assessment</td></tr>
<tr><td>Start value: 1</td><td>End value: 1</td><td>The system improved the ecosystem at 1 km of Ostrovsky Creek (Hajek site).</td></tr>
<tr><td colspan="3">Comments: Before the Wetland+® system installation, the ecosystem conditions in the creek were bad (high concentration of contaminants, low biodiversity, low life quality).
The selected indicator is the measurement of biodiversity expressed by the number of phytobenthos (Diatoms) species, commonly used biomarkers of an aquatic environment. The observed increase in the number of diatom species (and Shannon index) was at the first part of Ostrovsky Creek from 0 species before the system commissioning (H index not determinable) to 25 species (H=3.62) after two years of operation. Similarly, in the middle of the length of Ostrovsky Creek, such an increase was from 3 species (H index=1.04) to 28 species (H=3.98). Only at the end of the creek (before the inflow to Horní Štít pond) did the values not increase significantly (from 35 to 38 and H=4.72 and H=4.35). More time is needed to clean the sediments and increase the biodiversity here.</td></tr>
</table>

At the end of the project, the ecosystem quality is very good/high, and this trend will stay for the next period. The trend was overall stable prior to installation because no water quality changes were expected without any measures. During the project period, the tread was improving. In the next period, an improvement is expected (the flushing of water sediments by clean water and another development of biodiversity).

Indicator 10.2 Involvement of non-governmental organisations (NGOs) and other stakeholders in project activities – Private profit

Start value: 2	End value: 12	Number of stakeholders involved due to the project

Comments: Privat companies were involved in project activities in four different ways.
The first group are companies participating as project beneficiaries, the second group are companies involved in the advisory board, the third in constructing the Wetland+® system (subcontractor), and the fourth are potential clients for technology replication on other sites.

Start value: The project beneficiaries represent two private companies that are interested in commercializing the technology – PWT and SERPOL. During the project duration, they were very active in getting informed potential clients to replicate the technology.

End value: The number of involved organisations increased, from following groups, mainly:

- In the Advisory Group members, there were representatives of three companies, namely TAUW, an environmental engineering consultancy, SOLVAY, a large international company operating in more than 40 countries, INOVYN, a large chemical industry.
- The private companies were contracted to construct the Wetland+® system on both localities. They are interested in replicating the technology in other localities. Namely, it was DEKONTA a.s, an international environmental services and technologies supplier, Brigadon Lease Sp., and EKOMAR Sylwester Szcześniak, from Poland.
- Companies interested in replication and taken to the Replication Conveyor Belt: DND BIOTEC H (Italy), interested in bioremediation processes, Spolchemie (Czech) solving similar problems with other POPs compounds, Oltchim (Romania) a producer in chemical industry, CDM (Germany).

Indicator 10.2 Involvement of non-governmental organisations (NGOs) and other stakeholders in project activities – Public bodies

Start value: 5	End value: 30	The number of stakeholders involved due to the project.

Comments: Privat companies were involved in project activities in five different ways.

Start value: There were five organizations involved in the project as beneficiaries, namely Technical University of Liberec (coordinator, Czech), Aarhus University (Denmark), DIAMO, state enterprise (Czech), Central Mining Institute (Poland), City of Jaworzno (Poland).
End value: The number of involved organisations increased, from following groups, mainly:

- There were two national co-financing organisations – the Czech Ministry of Environment (co-financing of the project) and the Polish National Fund for Environmental Protection and Water Management (co-financing of the project).

- Advisory Board members are from the following public bodies: IWA international association, La Sapienza University of Roma (Italy), Spanish National Research Council (CSIS) (Spain), Aligarh Muslim University (India), Goblerno de Aragon (Spain). - The local Czech organizations were involved in the socioeconomic survey and/or in the project's results concerning the environmental quality on both sites. It was the local Hunter´s Association in Karlovy Vary region, Bird watching Association, Fishermen´s Association, Municipality in Hajek, Municipality in Hroznetin, Ostrov nad Ohri Municipal Office, Karlovy Vary Regional Office, Ministry of Environment (local office in Karlovy Vary), Department of landscape protection, agriculture and revitalization of Karlovy vary local government, Botanic garden in Dalovice, Karlovy Vary Nature and Landscape Protection Agency, Water Protection Department in Karlovy Vary Czech Environmental Inspectorate, Agency for the Protection of Nature and Landscape of the Czech Republic, The Ohre Basin, Forest Administration Horni Blatna Hajek. In the project's sustainability phase, public and NGO organisations will also be involved in the survey. - The last group are organizations involved in the project as potential technology clients. On the Conveyor belt, there is a Spanish site, where Sociedad Aragonesa de Gestion Agroambiental (SARGA) and a public company of the Government of Aragon in Spain are involved.		
Indicator 11.1 Website - No. of unique visits		
Start value: 0	End value: 2000	Number of unique website visits
Comment: LIFEPOPWAT has a solid online presence on the website (https://cxi.tul.cz/lifepopwat/home) and on social media channels. On this website, one can find the basic description of the project, Stakeholders, project boards, Dissemination activities, Deliverables and Milestones, newsletters, other Documents, Photos, Contacts and Links. There are also locked documents for beneficiaries. To maximize reach and impact, the website activity was periodically monitored using tools such as Google Analytics, thus keeping track of relevant information. The total number of visitors to the website for 4 years (2020 – 2023) was 2,083. Most of the visitors came from Czech R. (965), Poland (210), Denmark (105), and France (102), which are the beneficiaries' countries. Moreover, many visits were from other states, e.g., Spain (122), USA (119), Netherlands (76), and Mexico (43). The project informed the general public through other channels as well: https://twitter.com/lifepopwat, https://www.instagram.com/lifepopwat/, https://www.linkedin.com/company/lifepopwat/, https://www.facebook.com/LIFEPOPWAT/?modal=admin_todo_tour. For the public the Layman´s report (DD8, https://cxi.tul.cz/lifepopwat/home) was prepared as well (also in the Czech).		
Indicator 11.2 Other tools for reaching/raising awareness of the general public - Number of articles in print media (e.g., newspaper and magazine articles)		
Start value: 0	End value: Information boards: 2 Newspaper articles: 25 Event organised: 2 Scientific papers: 5 Videos, leaflets: 8	Number of outcomes (reports, events, etc.)
Comment: Reaching and raising of project awareness was carried out along several lines:		

- Information boards were installed at both sites at the beginning of the project about the project, its objectives, the LIFE programme and the specific installation at the site. These boards were left at the sites after the end of the project.
- Results of the project were presented on many international conferences (see above) and decribed in five scientific papers (some of them published, some submitted).
- The project was also announced to the general public by various channels of communication. In all countries of beneficiaries, there were articles in printed media. The complete list is in the Appendix of the DD7 deliverable. Overall, there were 25 articles in national and local printed or electronic media, most of them in Czech (18), Polish (5), and French (2).
- A press conference in Hroznetin (CZ) with about 10 journalists (8.7.2020). A meeting in Hajek for local inhabitants (around 40 people) on 08/09/2022 in occasion of LIFE 30. anniversary.
- Besides the printed (or electronic media), the project was repeatedly announced on radio and TV broadcasting in the Czech R. (see the Appendix of the DD7 deliverable), namely 6x on the Czech radio and 3x on TV. There were also prepared leaflets in three languages (in EN, CZ, PL, 2050 coppies in total). The project also prepared a special video (presented on the project web pages).

Indicator 12.1 Networking - Members of interest groups / lobby organisations, Representatives of interested groups (remediation experts, waste treatment companies)		
Start value: 0	End value: 20	No. of individuals

Comment: Networking was carried out through presentations of the project results at scientific conferences, where personal meetings with potential candidates for technology applications also took place. The second channel was direct contact with owners or organisations responsible for contaminated sites. Several visits to pilot sites were also made during the project to inform about the benefits of the Wetland+® technology. The last channel was to inform the general public and professionals during visits to TUL, where a 3D model of the site was created at a scale of 1:87 (H0 scale).

List of experts (and organizations) contacted:

- Dr. Fabio Masi, IWA Fellow Technical Director, IRIDRA Srl.
- Prof. Jan Vymazal, IWA, Czech University of Life Sciences, member of AB
- Prof. Marco Petrangeli Papini, La Sapienza Roma, member of AB
- Dr. Joseph Maria Bayona, Spanish National Council, member of AB
- Prof. Nadeem Khalil, Aligarh Muslim Univeristy, India, member of AB
- Prof. Ulo Mandel, University of Tartu, member of AB
- Elena Cano Lazaro, Gobierno de Aragon, Lindanet Project, member of AB
- Mathias Broquaire, SOLVAY, member of AB
- David Cazaux, INOVYN, member of AB
- Tobias Praamstra, TAUW, project HCH in Europe, member of AB
- Bourdewijna Fokke, project HCH in Europe, member of AB
- Dr. Tereza Hnatkova, DEKONTA a.s., Czech University of Life Sciences
- Dr. Katerina Chmelikova, Czech University of Life Sciences
- Dr. Petra Najmanova, DEKONTA a.s.
- Prof. Mario del Pino Palazios Diaz, Universidad de Las Palmas de Grand Canaria
- Dr. Vanessa Reyes Mendoza Grimon, Universidad de Las Palmas de Grand Canaria
- Guiherme Silva, Finacor Agro-Alimentar, Portugal
- Dr. Anacleto Rizzo, Iridra, Italy
- Fabio Manuel Viveiros Sousa, Fundacao Gaspar Frutuoso, Portugal

- Helder Dinis, Cooperativa Uniao Agricola, Portugal - H.E. Phasporn Sangasubana, Ambassador of the Kingdom of Thailand to CZ - Helena Langsadlova, Ministry for Science, Research and Innovation, CZ - Ing. Jaroslav Kopta, Chamber of Commerce, Liberec District, CZ - Jiri Krechl, CzechInvest, CZ - Damian Sanchez Garcia, Cetaqua, Spain - Jan Slunsky, Nanoiron, CZ - Bartolome Andre, University of Málaga, Spain - Jesus Fernandez Cascan, Gobierno de Aragon, Spain Gobierno de Aragon, Spain - Jorge Net, Sonia Velilla, Gobierno de Aragon, Spain - Ana Montero Garcia, Gobierno de Aragon, Spain - Douardo Calleja, Gobierno de Aragon, Spain - L. Monge, SARGA - Inaki Arrate Jorrin, Uraren Euskal Agentzia, Spain - Jose Maria Sanz De Galdeano Equiza, Uraren Euskal Agentzia, Spain - Josu Perea Arandia, Uraren Euskal Agentzia, Spain - Ignacio Quintana San Miguel, Ihobe, Spain - Agueda Pardo del Rio, Xunta, Porrino, Spain - Juan Manuel Camino Soto, Xunta, Porrino, Spain - Susana Franco Maside, Xunta, Porrino, Spain - Diego Fompedrina, Chminosil, Spain - Guillermo Serna, Chminosil, Spain - Thierry Ruffenach, TAUW, France - Sébastien Kaskassian, TAUW, France - Quentin Deparde, ARTELIA, France - Franck Le Moing, ADEME, France - Guillaume Masselot, ADEME, France - Frederique Cadière, ADEME, France - Michael Trump, State Office for Contaminated Sites in Saxony-Anhalt, Germany - Lukas Reinelt, State Office for Contaminated Sites in Saxony-Anhalt, Germany - Cossimo Masini, DND Biotech, Italy - Oliver Chilcott, ARKEMA company - Marine Leclerc, ARKEMA company - Marie Pascale Martin, ARKEMA company - Juliana Lecourt, ARKEMA company - Corine James, ARKEMA company - Massimo Marmoro, INOVYN company - Martin Forter, NGO, Switzerland

Indicator 13.0 Jobs		
Start value: 0	End value: 1.37	No. of new FTE
Comment: In addition to the existing staff, new employees were recruited to work on the project. As the scope (and amount of work) of the installation at site P1 in the Czech Republic is significantly larger, the indicator of new employees was assessed for the employees in relation to this site (employees of the Czech entities - TUL, PWT and DIA); no new employees were working at site P2, so this indicator is only related to the CZ site. In total, 4.55 FTEs worked on the project (P1) (as an average over the whole project period, calculated according to the Guidance document for LIFE projects), of which 1.37 FTEs were new employees. At the end of the project, these staff remained mostly in contract (excluding		

<table>
<tr><td colspan="3">agreements to carry the jobs). Specifically, there are 4 individuals in TUL, one in PWT and one in DIA. The Beneficiaries anticipate that these staff will remain in service and that their experience will be used in subsequent or related projects.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Indicator 14.1 Running cost/operating costs during the project and expected in case of continuation/replication/transfer after the project period</td></tr>
<tr><td>Start value: 0</td><td>End value: 3,087,031 €</td><td>Cost of the project</td></tr>
<tr><td colspan="3">Comment: The project end value equals the Total Eligible Direct and Indirect Costs really spent (3,087,031 €).
The system operation/maintenance costs after the project ends are estimated to be 10 thousand euros/a, so the costs after 3 years will be 3.2 mil €.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Indicator 14.2.3 Revenue expected in case of continuation/ replication/transfer after the project end.</td></tr>
<tr><td>Start value: 0</td><td>End value: 1 mil. €</td><td>Revenue is not expected now</td></tr>
<tr><td colspan="3">Comments: Non-applicable now. Revenue is expected after the end of the project. The project expects multiplications on other sites with revenue at a minimum of 1 million euros 3 years after the project ends. The potential sites for replications are in the Final report. Moreover, part of the consortium applied for another project, where the results of the projects are multiplied by other types of contaminations (agricultural drugs).</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Indicator 14.3 Future funding - Beneficiary's own contribution</td></tr>
<tr><td>Start value: 0</td><td>End value: 30,000 €</td><td>Maintenance costs</td></tr>
<tr><td colspan="3">Comment: Non-applicable now. After the project ends, the system operation/maintenance costs are estimated to be 10 thousand euros/a.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Indicator 14.4.1. Entry into new entities/projects</td></tr>
<tr><td colspan="3">At Jaworzno (PL), there is discussed a possibility of system extension to a larger scale.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Indicator 14.4.3 Entry into new geographic areas (CZ, PL, SP, GE)</td></tr>
<tr><td colspan="3">Comments: According to the Replication Conveyor Belt, ongoing negotiations exist on the possibility of the results' multiplication on other sites. The potential sites are in the Czech Republic, Spain and Germany. Of course, it is not sure that these replications will occur. On the other hand, sites in other states have been contacted.</td></tr>
</table>

KPIs conclusions:
The KPIs set for the successful implementation of the project were met. These are not only the environmental indicators of improved water and environmental quality at the Wetland+® implementation sites, but also other types of indicators. The construction of the remediation system has been completed in the defined areas, system is working very well and we expect to continue to work in next years (and decades). Other indicators are related to the dissemination of project results and their possible replication at other sites. These indicators have also been met and give a great chance for further applications of the system at other sites. The last category is the project indicators - FTE of people involved and running costs, which were also met. However, there are also indicators that will be met up to three years after the end of the project. Here the team will strive to meet them (expected revenue, beneficiaries own contribution, entry into new geographic areas).

8. Comments on the financial report

The financial statements from the LIFE website were used. They were completed according to the LIFE project guidance document and also the discussions with our project monitor Mr Svoboda. This part includes:

- An overview of the costs incurred,
- Information about the accounting system and relevant issues from the partnership agreements, and
- Allocation of costs per action.

8.1. Summary of Costs Incurred

PROJECT COSTS INCURRED				
	Cost category	Budget according to the grant agreement in €*	Costs incurred within the reporting period in €	%**
1.	Personnel	1,241,219	1,222,144	98
2.	Travel and subsistence	306,186	148,520	49
3.	External assistance	244,800	250,166	102
4.	Durables goods: total non-depreciated cost			
	- *Infrastructure sub-tot.*	0	0	0
	- *Equipment sub-tot.*	25,025	9,706	39
	- *Prototype sub-tot.*	773,120	927,607	120
5.	Consumables	197,950	182,528	92
6.	Other costs	147,698	106,920	72
7.	Overheads	205,517	199,300	97
	TOTAL	**3,141,515**	**3,046,921**	**97**

*) If the Agency has officially approved a budget modification through an amendment, indicate the breakdown of the revised budget. Otherwise this should be the budget in the original grant agreement.
**) Calculate the percentages by budget lines: e.g. the % of the budgeted personnel costs that were actually incurred

8.4. Certificate on the financial statement

Not applicable.

8.5. Estimation of person-days used per action

Action type	Budgeted person-days	Real person-days	Estimated % of person-days spent
A: Preparatory actions	263	234.47	89.15 %
B: Implementation actions	3,086	2,149.54	69.65 %
C: Monitoring of the impact of the project action	1,639	1,480.76	90.35 %
D: Public awareness/communication and dissemination of results	1,087	887.45	81.64 %
E: Project management	1,010	709.17	70.21 %
TOTAL	**7,085**	**5,461.39**	**77.08 %**

Note on personnel costs and person-days: work on days-off is possible and is taken as a working day, whereby increasing the work fund.

9. Envisaged progress until next report

Not applicable

10. List of Annexes

a. Consolidated Financial statement incl. Payment Request 2x1 (XLS, PDF)
b. Financial statement per partner (XLS document + 1st page signed) 2x7 (XLS, PDF)
c. List of deliverables and milestones 1x
d. Comments to MIS4LET 231110 from 04.12.2023 1x
e. Required documents to MIS4LET 231110:
   - DIAMO – documents include the project reference
   - SERPOL – documents include the project reference, payment confirmation, budget shift in FS
   - TUL - timesheets
f. Final inspection and permanent operation of the Wetland+ system at the Hájek site 1x
g. Sworn statement of TUL 1x
h. Amendment to the Partnership Agreement 1x