LIFE Project Number

<LIFE20 ENV/IT/000572>

Progress Report

Covering the project activities from 01/10/2021[1] to 30/09/2023

LIFE PROJECT NAME or Acronym

<LIFE SEDREMED>

Data Project

Project location:	
Project start date:	<01/10/2021>
Project end date:	<31/03/2025> **Extension date:** <31/05/2025 >
Total budget:	€ 2,591,866
EU contribution:	€ 1,425,526
(%) of eligible costs:	100

Data Beneficiary

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[1] Project start date

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2. List of key-words and abbreviations

KPI – Key performance indicator
LCA – Life Cycle Assessment.
LCC – Life Cycle Costing.
PMP – Project Management Plan
SIA – Social Impact Assessment.
TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies).
TRL 8 – system complete and qualified.
GIO – Grant innovation office
PMT – project management team
IPR – Intellectual property rights
PAHs – Polycyclic aromatic hydrocarbons
PCB – Polychlorobiphenil
PCDD – Polychloro-dibenzo-p-dioxine
EKO – Ekogrid
IDRA – Idrabel
INV – Invitalia
NIS – Nisida
ISO – Isodetect
SZN – Stazione Zoologica Anton Dohrn di Napoli
UNIVPM – Università Politecnica delle Marche
GIO – Grant innovation Office
ERM – Effect range median
DST – Deep Sea Technology

3. Executive Summary

LIFE SEDREMED aims at demonstrating the efficiency of an innovative in-situ remediation methodology adapting and combining 2 existing technologies that are commercialised at TRL9 for the remediation of soil/groundwater and reduction of organic matter in sludges, but that are not yet applied for decontamination of heavily polluted coastal marine sediments.
The project proposes the (1) installation of an electro-kinetic system (EKO) and the (2) application of biofixed microorganisms (IDRA) to speed the bioremediation of contaminated sediments. LIFE SEDREMED solution will start at TRL6 and it is expected to reach TRL8 during the project's implementation. The solution will be complemented by innovative and up to date monitoring methodologies to assess the efficiency of the remediation technologies and the benefits on biodiversity and key attributes of ecosystem functioning.
Specific objectives (and related actions):
· Uptake of characterization results to develop a technology/treatment train for the bioremediation of contaminated sediments (Actions A1 e A2)
· Run mesocosms trials (up to 1000 L) at prototype scale to ensure adaptation of technologies to the marine sedimentary matrix and maximum remediation efficiency during in-situ treatment (Action B1)
· Remediate 2 ha and 40000 m^3 of marine contaminated sediments to comply with EU (2000/60/EC, 2008/56/EC, 2008/105/EC) and Italian Legislation (Dlgs 172/2015) (Action B2)
· Demonstrate the synergy of the proposed actions with the existing decontamination plan, acting on total sediment decontamination and reducing pollutant concentrations prior to eventual dredging interventions, reducing environmental risks and lowering sediment handling costs (from 150 to around 25 € per m3) (in compliance with DM 173/2016) (Action C1)
· Develop a detailed technology transfer manual and business plan to promote its replication and close to market uptake in other contaminated coastal areas around Europe (Action B4)
· Creation and operation of Mediterranean Remediation Knowledge and Innovation hub (MEDREHUB) focusing on environmental bioremediation technologies (Action B5)
· Compare efficiency between 2 areas that have different levels of contamination through the use of advanced monitoring tools (Action B3)
· Assess benefits on biodiversity and ecosystem services and demonstrate synergy between *in-situ* remediation and the recovery of the natural capital (Actions B3 C1)
· Divulgate results to the general public, policy makers and managing authorities (Action D1)
All preparatory activities (Action A1 and A2) are completed in time.
In the deliverable A1, technical requirements for the sampling campaign have been established in order to engage a specialised subcontractor company and specific sampling points have been selected, replacing one of the initial areas described in the proposal. Within this deliverable, the partners considered logistical, safety, environmental and administrative aspects. Deliverable A2 shows the first authorizations obtained for carrying out the sampling activities.
Sampling activities started in July 2022 to collect sediment samples for lab scale and mesocosm experiments (action B1) and in December 2022 for the collection of sediment core down to 170 cm for monitoring activities (action B3) and for trials of the *in-situ* monitoring of natural attenuation capacity of the allochthonous microbial assemblages based on the installation of an innovative device (BACTRAPS).

Prototype EKO-IDRA technology has been optimised and successfully implemented in mesocosm (containing 50 L sea water and 30 Kg Bagnoli sediments). The two technology providers (EKO and IDRABEL) faced technical problems in the development and combination of their technologies during the ex-situ experiments (mesocosms), which determined a delay in the production of the first mesocosm results. In the annual meeting held in Brussels, EKO and IDRA presented a solution to face such technical problems by optimising the experimental conditions of the EKO-IDRA ex-situ technology. Therefore, 3 mesocosm run experiments have been recently started (early May) in parallel using freshly collected Bagnoli sediments. In this way, the first scientific results should be available by July 2023. These results will be used to optimise a second batch of mesocosm experiments scheduled for the end of July and the related results are expected by September 2023.

First monitoring analyses were performed by ISO and UNIVPM to develop their methodologies to be carried out during *in-situ* technology experiments and define the baseline conditions before remediation treatment.

The preparatory activities for the *in-situ* technology implementation are ongoing. A draft work plan of the activities to be implemented were discussed between partners involved, and the external company responsible for installing the technology has been contacted by SZN to intervene at the latest in October 2023.

The assessment of the environmental sustainability of the tested technologies, and social impact of the project will be carried out by UNIVPM through LCA and SIA (Social Impact Assessment). In particular, the environmental sustainability of the tested technologies will be compared to other reclamation options (e.g., dredging, transport and disposal in confined sites). LCC analysis will be performed by external consultants, the Blue Synergy company, due to the lack of robust expertise in this field of all partners involved in the project. The first list of environmental and social indicators was defined at project level, starting from the preliminary list provided in the KPI table.

The first snapshot of the KPIs was uploaded in July 2022 and was verified by CINEA (action C1).

Concerning the dissemination and communication activities of the project, the first structure of the Exploitation Plan was described in deliverable D1.1. The first divulgation event was successfully held in Brussels after Project's annual meeting last February. The event format included an expert roundtable, and the LIFE SEDREMED partners engaged with Belgian and European experts focusing on two thematic pillars of sediment management:

- Technological solutions and EU funding for sediment remediation and sustainable management;
- Policy barriers and best-practices in Member States for management of contaminated sediments.

Within the Action E1, in January 2022 a PMP was delivered to provide a single point of reference on the quality assurance processes that will be governed during the course of the LIFE SEDREMED Project. Furthermore, the risk and contingency plan was written by SZN and will be updated during the project.

4. Introduction

- **Description of background, problems and objectives:**

Environmental contamination by PAHs and heavy metals is reaching a global dimension and represents a serious risk for the sustainable provision of ecosystems' goods and services and human wellbeing. In Europe, environmental contamination is often linked to intense industrial activities, that in many cases, are located near the coast, representing a high ecological risk for both terrestrial and marine environments, even after the end of the industrial exploitation (*Armiento, 2020*). This issue is widely widespread; indeed, it was estimated the presence of 2.5 million polluted sites in the EEA-39, specifically where industrial activities took place (EEA, 2019). To date regeneration efforts of dismissed industrial sites have proved to be unsuccessful, revealing the need of efficient remediation methodology. Conventional remediation practices of marine sediments can be highly costly and could cause major environmental impacts. Typically, they are exerted *ex-situ* through mechanical dredging of the contaminated sediments, causing the remobilisation of pollutants. Among the most polluted coastal areas in Italy there is the Bagnoli site, located in Naples (IT). Bagnoli is one of the areas identified at high risk of environmental crisis in Italy and it has been included (Law 388/ 2000) in the list of polluted sites of National interest (SIN). The site, now dismissed since 1990, was characterised by steel industry, asbestos processing, fertiliser and concrete farms. Knowledge on benchmark contamination is well developed and a complete characterization of the contamination in this area (14 Km2) is available thanks to ISPRA (BoI-Pr-CA-BA-relazione-02.04) and to the ABBACO project recently concluded (2020) and led by SZN and UNIVPM, coordinator and partner of this project, respectively. Bagnoli's sediments contamination is characterised by high levels of: PAHs (up to 2800 mg/Kg), PCBs (ranging from 25 to 155 ug/kg), PCDDs (up to (316 ng/kg), As (845 mg/kg) and heavy metals, such as Pb, Zn, Cd, Cu and Hg. These values not only largely exceed the thresholds of the chemical quality of marine sediments established by the Italian law Dlgs 172/2015, but can also have major detrimental biological and ecological consequences which hamper the achievement of the good environmental status required by the Marine Strategy Framework Directive (2008/56/EC) and the Environmental Quality Standard Directive (2008/105/EC). The site's contamination has also a particularly high impact on human health and socio-economic development as it is located in the peri-urban area of the city of Naples and on the coastline. The coast hosts several mussel cultivations and fishery activities; therefore, contaminants bioaccumulation can potentially pose threats for human health.
In this framework, the LIFE SEDREMED project will demonstrate the cost-efficiency of *in-situ* bioremediation of different types of toxic contaminants, present in the Bagnoli's sediments, through the adaptation, combination and field implementation of 2 innovative *in-situ* remediation technologies, such as IDRA and EKO.
For the first time a holistic approach will be implemented, combining the 2 selected remediation technologies as well as advanced monitoring methods in order to reduce and verify the concentration of heavy metals and hydrocarbon contaminants up to 80% and to save up to 6-times of remediation costs compared with the ex-situ remediation approaches.

- **Expected longer term results:**

The involvement of INV managing the interested contaminated site will ensure ownership, commitment and continuation of project actions and results. As a matter of fact, this project is in line with the techno-economical plan published in June 2020 by INV, demonstrating

the strong commitment of INV and the Italian Government for the requalification of the Bagnoli area. The implementation of the LIFE SEDREMED methodology will facilitate INV to reach its objectives, lowering the costs compared to conventional excavation and *ex-situ* methods (150€ per m^3 versus 25€ of LIFE SEDREMED). INV also manages over 20 contaminated industrial sites in Italy, some of them characterised by coastal and marine sediment contamination. Its involvement will thus facilitate continuation in Bagnoli and replicability and transferability in other polluted sites. Furthermore, according to data provided by the EEA in 2019, around 2.5 million sites are polluted (terrestrial, marine and freshwater) where industrial activities have taken place. The validation of the LIFE SEDREMED approach in Bagnoli, could result in its replication by other companies managing contaminated sites that will have a financial interest in exploiting the project's actions in addition to the clear environmental benefits. The participation in the consortium of technology providers will ensure the prompt availability of the necessary know-how for continuation of actions and their replication in other European contaminated sites. EKO has already several partnerships across Europe and will implement findings with its local partners enabling divulgation and replication in Northern Europe. IDRA will implement findings and enhancement of its technology in Belgium and the Netherlands where it already biologically treats several canals and water basins. The involvement of SZN, UNIVPM, and NIS will enable an efficient divulgation of project results in the Italian and European research sector and professional remediation sector. The stakeholders meeting and conferences (B4 and D1) that will be organised will increase knowledge of relevant local, regional, national and European authorities on the developed solutions and results achieved, ensuring the continuation of actions and results (some preliminary stakeholders have been already identified and contacted: SEDNET, Ministry of Environment, Campania Region, Commissario di Governo per Bagnoli, Institute for Environmental Research and Protection-ISPRA, Public Research Entity and clusters like CNR, ENEA and Blue Italian Growth, local environmental associations such as LEGAMBIENTE). Furthermore, the "MEDREHUB" (Action B5) will serve as a platform to prepare other public and privately funded projects in the bioremediation and environmental reclamation sector.

5. Administrative part

LIFE SEDREMED partnership is composed by an inter-sectoral group of 7 partners from 4 EU countries (IT, BE, DE, FI): Stazione Zoologica Anton Dohrn (SZN, Coordinator), Polytechnic University of Marche (UNIVPM), Invitalia (INV), Idrabel (IDRA), Ekogrid (EKO), Isodetect (ISO), Nisida Environment (NIS). The partnership agreement was signed on 01st March 2022. The scientific coordinator is Donatella de Pascale, director of Ecosustainable marine biotechnology department at SZN, supported by a financial coordinator of SZN (GIO) and project manager (Chiara Melchiorre). The consortium has a multidisciplinary character embracing different expertise and strong experience in both research activity and technology provider. Moreover, the coordinator (SZN), has extensive experience in advanced research in coastal and marine biology and ecology, and the Ecosustainable Marine Biotechnology Department has relevant knowledge in the *in-situ* remediation techniques and will provide ship facilities for actions implementation. The Steering Committee (SC) is composed by 9 members: the Project Coordinator (as chair), the Project Manager and 7 representatives, one for each LIFE SEDREMED partner, selected on the basis of their scientific skills, technical expertise and project implementation experience is part of the SC). The SC meets as needed (follow up meetings) to discuss the progress of ongoing actions. There is also constant communication (via mail or short call)

between coordinator (SZN) and partners to address specific project activities, share important information or discuss about specific issues. The whole consortium meets once a year in the general assembly (GA) meetings to review and provide feedback on operational reports presented to them by the PMT. The first two GA meeting were held in Naples, Italy on 1st-2nd December 2021(Kick-Off Meeting) and in Wavre/Bruxelles, Belgium on 7th – 10th February 2023 (1st Consortium meeting). By January 2024 will be organise the 2nd consortium meeting in Rome, Italy and the 3rd consortium meeting will take place in Finland at EKO premises by September 2024. The final conference is scheduled at the end of the project (March 2025) in Naples at SZN premises. A Google Drive folder has already been created containing all the relevant information or data produced since the Kick-Off meeting. All partners have free access to the folder. It will be updated during the entire project duration. All the financial and administrative aspect are also carefully assessed by SZN. Until May 1, 2023 (change of monitoring mode by CINEA) SZN was in constant communication with the NEEMO monitoring team (Yael Meroz), to inform about the progress of the project and about issues such as deviations from the work plan or problems financial to solve. Two monitoring visits with NEEMO have been organized so far, one in April 2022 at SZN in virtual mode with other partners, and one during the GA meeting in Belgium. There has been also direct communication with the CINEA project officer to communicate first issues addressed and needing to postpone mid-term reporting. From 01/05/2023 CINEA inform coordinator Donatella de Pascale about New-LIFE-external-monitoring-support. The changes related to the external monitoring team that supports us and CINEA during the projects' lifetime were shared with all SEDREMED partners, and the access to the LIFE Monitoring Helpdesk was created for PC (donatella.depascale@szn.it) and PM (chiara.melchiorre@szn.it).
There have not been any changes due to amendments to the Grant Agreement.

6. Technical part

6.1 Technical progress per Actions

Action A1 – Definition of the sampling plan (M1-M4)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
10/2021	11/2021	01/2022	01/2022	Completed with a short delay

Table 1 Status of Deliverables and Milestones – Action A1

Deliverables	Foreseen date	Status	Annex
Design of the sampling campaign	01/2022	**Done on time and provided in the 1st visit** (expected with the MTR).	**6.1.1**
Milestones	**Foreseen date**	**Status**	
Sampling points selected	11/2021	Achieved with a short delay in 01/2022.	

Action Leader: SZN

Partners involved: UNIVPM, INV, ISO, EKO, IDRA

During the project kick-off meeting the beneficiaries discussed the **selection of the sampling locations, timing, equipment, facilities and number of samples**, based on the available data acquired by the ABBACO project, in which SZN, UNIVPM and INV participated. The discussion highlighted that the North Pier, which hosts one of the areas initially selected (Areas 20/30 and 63/72), is structurally unstable and that it presents some logistical difficulties (no electricity supply for EKO's equipment). Based on these considerations, the two areas selected are near the South pier: (i) in front of the "Colmata", and (ii) near "Circolo Ilva". They have Low - High contamination level.

These two sites were selected based on different criteria (i.e. **geological, sedimentological and hydrodynamic characteristics**) and are:

(i) **Site L** (Lower contamination; Area 70 from ABBACO, Città della Scienza/ Circolo Ilva (Sediment Class: C-D), closer to the coast.

(ii) **Site H** (Higher contamination, Areas 60/61 from ABBACO, located next to the South pier (Sediment Class: D-E).

The ABBACO project has provided a precise idea of the distribution, concentration and typology of pollutants, composition of the sediments, and depth in both areas.

ISO, SZN and UNIVPM have closely and effectively collaborated to design the sampling plan (see Action B1). The plan foresees sediment sampling at selected points in those areas in order to: (i) chemically characterise the sediments (Action B3), (ii) perform lab-scale and small mesocosms experiments (Action B1), and (iii) map the area for the *in-situ* implementation (Action B2). The sampling of sediment cores (action B1) is foreseen in conjunction with the installation of the EKO electrodes (Action B2).

Action A2 – Permitting and procurements (M1-M6)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
10/2021	11/2021	03/2022	07/2022	Completed with a 4-month delay

Table 2 Status of Deliverables and Milestones – Action A2

Deliverables	Foreseen date	Status	Annex
Authorisations and procurement report	03/2022	**Completed with a short delay in 06/2022.** A document describing the tasks needed to have all authorisations was provided in the 1st visit (INV has informally pre- compiled the template for the request) and eventually, all authorisations have been obtained by 06/2022.	**6.1.2**
Milestones	**Foreseen date**	**Status**	
List of all authorisations and procurements needed	12/2021	Available since 01/2022	

Action Leader: INV
Partners involved: SZN, ALL

INV is in charge of obtaining the necessary authorisations, also based on discussions and decisions taken in Action A1 (on the sampling sites and related modifications). Discussions showed that most of the needed permits are internal documents of INV and that only one - for the *in-situ* operations - should be provided by Naples' Port authorities.
In June 2022 SZN engaged Deep Sea technology and received the authorizations needed to gain access to the marine protected area of Bagnoli and to collect sediments.
However, due to technical issues within DST, it was not available for the first sediment sampling scheduled in July 2022. Therefore, SZN requested support from its sampling company which carried out the first sampling of the sediments.
From 30 November 2021 to 31 December 2025 (Paragraph 11 - bis of art. 33 of the Legislative Decree no. 133/2014, converted into Law no. 164/2014, as amended by Law no. 233/2021) the Mayor of Naples, Prof. Gaetano Manfredi, has been appointed Extraordinary Commissioner for the environmental reclamation and urban regeneration of the Bagnoli-Coroglio area of significant national interest. All sampling activities are therefore now communicated in advance to the Extraordinary Commissioner of Bagnoli which deals with permits for the entire Bagnoli area.

Action B1 – Sampling, adaptation, calibration and prototype implementation in mesocosms (*ex-situ*) (M6-M30)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
03/2022	12/2021	08/2024		Started earlier

Table 3 Status of Deliverables and Milestones – Action B1

Deliverables	Foreseen date	Status	Annex
Ex-situ bioremediation and prototype implementation	03/2023	Completed with few months delay 06/2023. The deliverable will be updated till the end of the action	**6.1.3**
Sampling campaign report	08/2024	Ongoing, scheduled on time	
Milestones	**Foreseen date**	**Status**	
First contaminated sediments collected	06/2022	Completed with short delay (1st sediments collection 14/07/2022)	

Action Leader: IDRA
Partners involved: EKO, SZN, ISO, UNIVPM

Initially, the activities related to the *ex-situ* experiments were expected to take place in dedicated mesocosms at the SZN facility. After several technical meetings, all partners involved in this action decided to move all mesocosms activity at IDRABEL premises, in order to facilitate technology providers the logistics to optimise the adaptation of their technology.

- *Ex-situ lab test:*

EKO and IDRA have been working together to combine Bio-Vase (IDRA product) with the EKO technology. Different configurations will be used changing the particles size. Bio-Vase composition is Masse + Zeolites + pumice stones + calcium carbonate + aluminosilicates.
In early 2023 IDRA defined the type of products (Bio-Vase composition) and adapted it to EKO technology. They optimise the experimental system conditions.

- *Mesocosms Set up:*

IDRA and EKO, supported by UNIVPM, ISO and SZN, started mesocosms activities at IDRA premises. In particular, IDRA and EKO perform (set-up) tests with artificial sediments (sand + clay) with the following objectives:
1) Assess the impact of electrodes on physico-chemical parameters (pH, redox, O2, conductivity)
2) Identify the migration speed of particles (colourants and microbes)
Prototype EKO-IDRA technology has been optimised and implemented in mesocosm containing 50 L sea water and 30 Kg Bagnoli sediments. The two technology providers (EKO and IDRA) faced technical problems in the development and combination of their technologies during the *ex-situ* experiments (mesocosms), which determined a delay in the production of the first mesocosm results. The first Run1-3 mesocosm experiments did not produce significant results. The experimental design for the second round of experiments (Run4-6) is being optimized.

- *Sampling Activities*

SZN contacted several sampling companies and got only a quote from Deep Sea Technology (two other companies - Next Geosolution and STS-SAS - replied that they are not available). Therefore, DST was selected. SZN's own sampling team supports the process.

According to the joint development of a detailed sampling design (see Action A1) adequate logistic and technical details were defined to guarantee the proper collection, storage and transport of sediment samples for the analyses in the laboratories of UNIVPM, SZN and ISO. For preliminary monitoring analysis carried out in July 2022, sediment samples collected in the area identified for the *in-situ* experiments were characterised in terms of chemical contamination. To this aim, UNIVPM, SZN and ISO discussed and agreed on a sampling strategy and defined the set of variables to be analysed. In particular, surface sediment samples (the top 20 cm) were collected in July 2022 by three independent Van Veen grab sampling in a single site (40°48.350' N, 14°10.020' E) and subsequently analysed for the concentrations of main contaminants previously identified during the ABBACO project, which include metals/metalloids (i.e. Al, As, Ba, Cd, Cr, Fe, Mn, Ni, Pb, Cu and Zn), hydrocarbons C>12 and sixteen different PAHs congeners of priority concern (i.e, naphthalene, acenaphthene, fluorene, acenaphthylene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3,-cd]pyrene, dibenzo[a,h]anthracene, benzo[g,h,i]perylene), which sum represents the total concentration of PAHs. Additionally, *ad hoc* laboratory assays were carried out to monitor over time the bioremediation performance of a new version of Bio-Vase formula developed by IDRA.

In December 2022 core sediment samples were collected from the same site by DST (hereafter defined as heavy-contaminated pilot test site H, 40°48.349'N; 14°10.020'E) and in an additional area (hereafter defined low-contaminated pilot test site L: 40°48.294'N; 14°10.076'E) by using a vibrocorer. In each selected area, two independent sediment cores, down to ca. 170 cm depth, were recovered and sliced into different sediment layers (e.g., 0-50 cm, 50-100 cm, >100 cm). These samples have been analysed by monitoring tools (see Action B3 #1, #2, #3 and #4) and for laboratory assays (see Action B3 #7). Altogether, sediment material was collected from 16 sediment layers (2 sites x 2 cores x 4 sediment depths).

For *in-situ* monitoring of biodegradation performance (see Action B3 #6) ISO developed special lancets containing microcosms with labelled (^{13}C & ^{2}H) polycyclic aromatic hydrocarbons (BACTRAPS). BACTRAP lancets were inserted on November 4th, 2022 at two different depths into the sediment (0-15 cm and 20-35 cm) of each test field and contained BACTRAPS loaded either with $^{13}C/^{2}H$-naphthalene or $^{13}C/^{2}H$-acenaphthene. All the BACTRAPS were successfully recovered on January 27th 2023, after 83 days of in situ exposition.

In April 2023 SZN collected fresh surface sediment samples (the top 20 cm, ca. 100 kg) just as in July 2022 and sent them to IDRABEL to run mesocosm experiments.

Action B2 – On-field implementation in the contaminated areas of selected technologies (*in-situ*) (M18-M35)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
03/2023	02/2023	08/2024		**Ongoing, there is a 1 month delay**

Table 4 Status of Deliverables and Milestones – Action B2

Deliverables	**Foreseen date**	**Status**	**Annex**
Detailed work plan of the activities to be implemented	04/2023	The design of the electrodes has been simplified 30/06/2023. The changes make the installation easier and faster. A drafted deliverable is provided	6.1.4
In-situ bioremediation approach and prototype implementation	08/2024	Ongoing, Scheduled few months delay	
Milestones	**Foreseen date**	**Status**	
Logistical infrastructure set-up	05/2023	Ongoing. Few months delay	

Action Leader: EKO
Partners involved: IDRA, SZN, INV

- *Logistical infrastructure set-up:*
The position of the EKO unit and cabin control are established. The EKO unit has to be electrified, INV is providing a solution for the space and electricity needed from a nearby building. INV and SZN is still working to ensure all logistical infrastructures to install correctly the EKO technology.
- *Technology installation costs*:
To face the high installation costs, SZN proposed to install the technology simultaneously in the two pilot test sites (L and H) and asked Deep Sea Technology for a double quotation (installation of the technology in one test site and in two test sites simultaneously) to evaluate the most feasible way.
- *Prototype implementation:*
The design of the technology installation plan was discussed by the partners involved and defined as follows:
9 electrodes (EKO) will be installed for each pilot test site in a 10m x 10m area, spaced 5m apart. All electrodes will be electrified and the cables will be transported to the control unit inside special ducts to avoid vandalism and accidental damage. 18 IDRA pipes will be installed in only half of the test field area. (Figure 1).

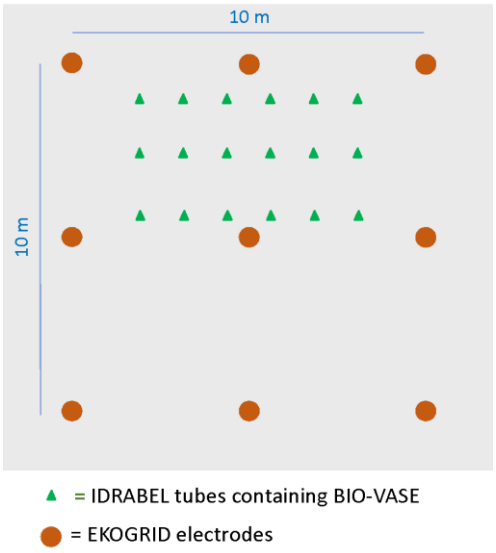

Figure 1 Scheme of in-situ technology installation. This design will be adopted for both pilot test fields (H and L)

The *in-situ* technology installation is scheduled for October 2023.

Action B3 – Control of chemical, microbial and ecological effects of remediation technologies (degradation, synergies, progression, biodiversity) by elaborated monitoring tools (M6-M35)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
03/2022	03/2022	08/2024		Ongoing

Table 5 Status of Deliverables and Milestones – Action B3

Deliverables	Foreseen date	Status
First report with monitoring results	10/2023	Ongoing, scheduled on time
Final report with monitoring results	08/2024	Not elaborated yet
Milestones	**Foreseen date**	**Status**
Results of first monitoring campaign available	10/2023	Ongoing, Scheduled on time

Action Leader: UNIVPM
Partners involved: SZN, ISO, INV

Action B3 aims at: i) monitoring the effectiveness of the SEDREMED *in situ* technologies for the remediation of the Bagnoli sediments by using state of art and innovative protocols and tools; ii) assessing the ecological compatibility of the *in situ* applied technologies and their potential benefits for benthic biodiversity and ecosystems functioning. The primary monitoring activity covers the quantification of chemical contaminants (i.e., metals/metalloids, PAHs, hydrocarbons C>12 and PCBs; tool #1, see Figure 1) prior to the installation and initiation of remediation treatments. A set of further innovative methods will be used to proof the effective enhancement of degradation processes: the determination of specific metabolites of degraded pollutants (tool #2), compound-specific isotopic enrichment of contaminants (#3), GC-MS fingerprinting (#4), molecular genetic analyses (e.g., qPCR, metabarcoding; #5), specific *in situ* microcosms (BACTRAPS, #6) and laboratory assays on the microcosm level (#7) (Figure 2).
To assess the environmental eco-compatibility and potential ecological benefits of treatments, bioassays based on different marine taxa (#8) and analyses of meio- and macrofauna abundance, diversity, and assemblage composition (#9) as well as key attributes of ecosystem functioning (i.e., organic matter degradation rates, #10) using a BACI (Before-After-Control-Impact) approach will be performed (Figure 2).

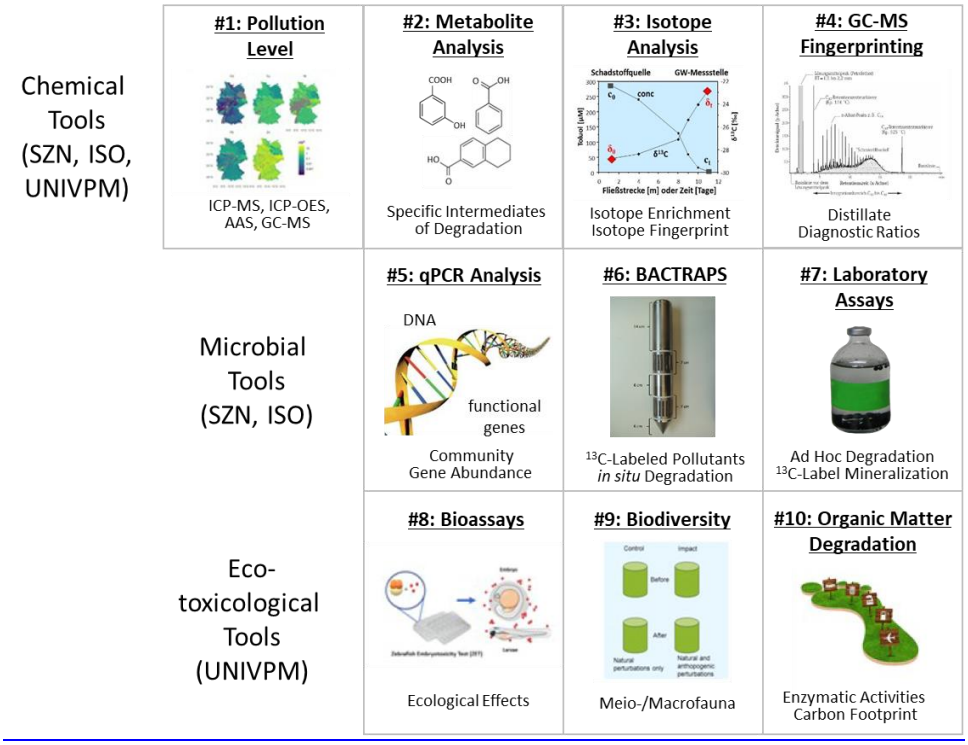

Figure 2 Foreseen monitoring tools for assessing chemical, microbial and ecotoxicological effects of the remediation technologies in SEDREMED

Achieved

#1) *Pollution level and potential ecotoxicological risk* (UNIVPM, SZN), *principle:* The analysis of pollutant concentrations and the assessment of their potential ecotoxicological risk is a prerequisite to define the baseline conditions where *in situ* technologies will be tested (*Dell'Anno et al., 2020*).

Results: The concentrations of the different contaminants in the sediment samples collected in July 2022 were high (see Table 1 in Annex 6.1.6) and most of these exceed the available threshold values reported in the DM 173/2016 and Dlgs 172/2015 for sediment quality. Among the different contaminants analysed, PAH concentrations were highly variable among replicate samples (coefficient of variation = 75%), indicating a high heterogeneity of the distribution of these contaminants in the sediment even at small spatial scale, which need to be carefully taken into account for a robust assessment of the performance of the selected remediation technologies when applied in situ.

Based on the available ERM values for metals and PAHs (*Long, 1995*), the m-ERM-quotient values were calculated for both typologies of contaminants to classify sediments according to their potential ecotoxicological risk (*Kowalska et al., 2018*). The m-ERM-q values obtained from heavy metal concentrations allow classifying sediments at medium-high risk (see Figure 1 in Annex 6.1.6). The m-ERM-q values obtained from PAH concentrations allow classifying sediments from medium-low (replicate R2 and R3) to medium-high risk (replicate R1; see Figure 2 in Annex 6.1.6).

Sediment cores collected in December 2022 allowed UNIVPM to evaluate chemical contamination also in deeper sediment layers (down to 100 cm) and its variability between the two selected sites (site H and site L; see Table 2 in Annex 6.1.6). As expected, sediments collected at site H were characterised by higher contaminant concentrations than sediments collected at site L. At both sites, the concentrations of several chemical contaminants

analysed greatly exceed the available threshold values reported in the DM 173/2016 and Dlgs 172/2015 for sediment quality. The concentrations of different chemical contaminants (both organic and inorganic) were similar or even higher in the 50-100 cm than in the 0-50 cm sediment layer. This pattern is consistent with that previously observed in the ABBACO project and further underlies the need to design *in situ* remediation technologies able to efficiently remediate not only the surface sediments but also the deeper sediment layers.

#2) *Metabolite analysis (ISO), principle:* The detection of metabolites from contaminants is a simple and quick method for providing evidence of *in situ* biodegradation (*Morasch et al., 2011).* It is applicable to a wide variety of aromatic and aliphatic hydrocarbons and allows discriminating between aerobic and anaerobic degradation processes.

Results: Besides benzoate, no specific metabolites of aerobic/anaerobic PAH degradation were detected, indicating limited natural degradation of PAH at the Bagnoli test sites (see Table 3 in Annex 6.1.6).

#3) *Compound-specific isotope analysis (ISO), principle:* To prove and quantify biodegradation, component-specific isotope analysis of carbon ($^{13}C/^{12}C$ CSIA) has become a key method for different chemical contaminants (e.g., BTEX, PAH; *US EPA 2008*). It is based on the concentration decrease and concomitant enrichment of the heavy C isotope (^{13}C) due to biodegradation. CSIA can be used not only to elucidate pollutant degradation, but also to discriminate contaminant sources by their isotopic fingerprint. However, it is generally limited to small molecules with less than 12 carbon atoms.

Results: Except naphthalene, all detected pollutants had more than 12 carbon atoms so that CSIA was not feasible to provide evidence for biodegradation. Thus, these analyses were postponed at a later stage considering that isotopic fingerprints might deliver insights into the variety of pollutant sources.

#4) *GC-MS fingerprinting (ISO), principle:* Certain distillates of oil contaminants can be analysed by GC-MS and SIM (single ion mode) in order to quantify specific components and determine certain diagnostic ratios, which indicate particular contamination processes or periods, the degree of degradation and weathering (*Galperin et al, 2008*). Moreover, the heterogeneity of contamination patterns can be highlighted.

Results: The concentration patterns of detected PAHs revealed major pollution occurring at different sediment depths of the investigated sites (see Figure 3 and Table 4 in Annex 6.1.6). Highest concentrations of PAHs (50 mg/kg) were found in the deep sediment layer (100 - ca. 130 cm) of pilot field H, while field L showed the highest value (20 mg/kg) at 25 - 100 cm depth. Remarkable small-scale heterogeneity was evident by comparison of replicate sediment cores (A, B) collected at each field, where total PAHs varied up to twofold. Regarding specific compounds, PAHs were generally dominated by fluoranthene and pyrene, but in some cases high concentrations of phenanthrene, dibenzofurane and dibenzothiophene were also observed (see Figure 4 in Annex 6.1.6). In contrast to the varying PAH level, the spectrum of PAH compounds was rather similar at both sites. SIM analyses revealed a lower load of methylated PAHs, since only methylated pyrenes and chrysenes were identified. Considering diagnostic ratios, alkylated PAHs did not display a relevant increase compared to the non-substituted PAHs, so that only limited PAH degradation could be concluded. However, alkylated PAHs were difficult to evaluate due to the high fraction of non-substituted PAHs (see Table 4 in Annex 6.1.6).

#5) *Molecular analysis (SZN, UNIVPM), principle:* Molecular analysis targeting specific genes involved in biodegradation pathways (by qPCR) and/or the whole microbial

community analysis (i.e., by 16S rDNA metabarcoding) can provide useful insights on the microbial responses due to applications of bioremediation strategies (*Winderl et al, 2008*).
Results: Analyses based on qPCR and potentially also metabarcoding have been planned after finalization of mesocosms and will be employed for the *in-situ* experiments.

#6) *BACTRAPS (ISO), principle:* BACTRAPS are *in-situ* microcosms containing substrates amended with an adsorbed ^{13}C-labeled contaminant. During their exposition in sediments, the substrates can be colonised by pollutant-degrading microorganisms, which assimilate the ^{13}C-label into their biomolecules such as amino acids (AA) and fatty acids (*Bahr et al, 2015*). The analysis of ^{13}C accumulation in these biomolecules will provide a semi-quantitative comparison of local biodegradation performance.
Results: Amino acid analysis revealed microbial colonisation of BACTRAPS after 83 days of incubation (1,7 - 2,5 mg total AA per BACTRAP; see Figure 5 in Annex 6.1.6). The ^{13}C AA isotope values ranged between -2 ‰ and +10 ‰. Generally, ^{13}C values of amino acids are negative and vary between -74 ‰ and 0 ‰, but they can reach values up to +11 ‰ depending on the utilised substrate. As the detected AA isotope values were below this limit, it can be concluded that *in-situ* PAH degradation is low. Nevertheless, a weak indication of natural attenuation can be deduced, since they are above the common natural range.

#7) *A) Laboratory assays: Degradation rates of PAHs regarding the performance of IDRABEL Bio-Vase product (UNIVPM), principle and experimental set up:* The degradation rates of PAHs present in the sediment can be determined by laboratory experiments in which PAH concentrations are monitored over time (*Dell'Anno et al., 2020*). Three different aerobic treatments with IDRABEL Bio-Vase product and a fourth one without any amendment (control, CTRL) have been used during time-course incubations lasting ca. 2 months. Treatment 1 was based on the addition of sterilised Bio-Vase product, treatment 2 was based on the addition of the original Bio-Vase product (i.e., containing fixed microorganisms), treatment 3 was based on the addition of specific bacterial and fungal strains (previously isolated from contaminated Bagnoli sediments) to sterilised Bio-Vase product.
Results: Sediments used for assessing the bioremediation performance on PAHs were characterised by different initial concentrations, especially in terms of low molecular weight congeners (see Figure 6 in Annex 6.1.6). Such variability of concentrations was even evident between replicate samples of the same treatment. Overall, total PAH concentrations at the end of time-course experiments decreased in treatment 1 (sterilised Bio-Vase), treatment 2 (Bio-Vase with fixed microorganisms) and in the control (without amendments; see Figure 7 in Annex 6.1.6). Generally, a decrease of low molecular weight PAHs was observed. Treatment 3 did not determine a remarkable decrease of PAHs over time.
On the basis of these results, it has been estimated that the allochthonous microbial assemblages present in the Bagnoli sediment can degrade after ca. 2 months of incubation ca. 60% of total PAH concentrations under aerobic conditions, suggesting a high natural attenuation capacity toward these contaminants when molecular oxygen is available. However, anaerobic conditions prevail in Bagnoli sediments (below 15-20 cm depth), but it has to be regarded that the EKOGRID technology could provide a remarkable switch of redox conditions close to aerobic level. The addition of Bio-Vase slightly improved the degradation yield, especially for the low molecular weight PAH congeners. Moreover, Bio-Vase might have a positive effect on the adsorption/immobilisation of heavy metals, which will be tested in future experiments. The degradation yields assessed by such experiments

should be viewed with caution due to the high variability of PAH concentrations between replicated assays and somehow artificial laboratory conditions.

B) Laboratory assays: Mineralization rates of ^{13}C-labeled pollutants (ISO) regarding the performance of IDRABELs Bio-Vase product, principle and experimental set up: The mineralization (i.e., degradation down to end-products) of an organic compound can be investigated in laboratory microcosms supplied with ^{13}C-labeled molecules of the compound (*Bahr et al., 2015*). When samples from the field site are incubated under *in situ* like conditions and a ^{13}C-labeled compound is added, mineralization will induce ^{13}C accumulation in potential end-products CO_2, CH_4 or ethene. By mass balance calculation, complete degradation can be proven and even quantified for defined environmental conditions. A total of 67 laboratory microcosms were set up either with ^{13}C-labeled naphthalene or phenanthrene. Mineralization was compared between sediments from different depths and from both test fields. Furthermore, the assays mimicked either anaerobic or aerobic conditions with varying amounts of Bio-Vase product provided by IDRABEL. To check potential abiotic reactions, inactivated controls were prepared.

Results: Aerobic microcosms from both sites without Bio-Vase product displayed an immediate and intense mineralization of phenanthrene and naphthalene, independently from sediment depth (see Figure 8 in Annex 6.1.6). Microcosms amended with Bio-Vase plus O_2 revealed a long lag-phase (> 50 days) followed by low mineralization rates of PAH. Notably, high oxygen consumption in comparison to Bio-Vase -free microcosm assays was observed. Thus, the Bio-Vase product initially stimulated aerobic microorganisms, yet not those performing PAH degradation.

Also, anaerobic PAH mineralization was proven by lab microcosms though with occasionally long lag-phases. For phenanthrene, it started after approximately 70 days of incubation in the surface sediment layer. Anaerobic mineralization of naphthalene started much faster (occasionally <5 days after incubation) and was evident with sediments collected at depth down to 100 cm. Therefore, we conclude that natural attenuation of *dissolved* PAH is evident in Bagnoli, yet highly diverse for specific PAHs. Generally, the behaviour of microcosms from different cores (within the same sites) was very similar. Thus, a widespread potential for microbial PAH degradation can be assumed despite local heterogeneities in contaminant distribution.

C) Laboratory assays: Mesocosms mimicking the performance of EKOGRID and IDRABEL remediation technologies. Principles and experimental setup of this approach are described under cross-cutting Action B1.

#8, #9, #10) *Ecotoxicological tools and ecological effects (UNIVPM, SZN), principles*: The impact of chemical contaminants does not rely only on the total concentrations, but also on their bioavailability and toxicity which in turns can determine major detrimental effects at different levels of biological organisation (i.e. from individuals to populations and communities). Thus, the assessment of *in situ* remediation technologies should take into account not only the decrease in contamination levels, but also the attenuation of ecotoxicological risks (*Morroni et al., 2020*) and the corresponding potential ecological benefits (*Mele et al., 2020*). This will be done using different bioassays on selected marine species and by the evaluation of meio- and macrofauna biodiversity and key attributes of ecosystem functioning based on a BACI design, i.e., organic matter degradation rates through the analysis of extracellular enzymatic activities).

Results: UNIVPM in collaboration with SZN elaborated a detailed strategy for sample collection which includes three different areas, where i) *in-situ* remediation technologies

will be applied, ii) only the operation for the installation of technologies will be realised (i.e., control artefact) and iii) natural conditions will be maintained. Data are not yet available due to the delay in the beginning of *in-situ* treatments by the technology providers (EKO and IDRA).

Preliminary conclusions

Several monitoring methods have been successfully applied on Bagnoli sediments to provide a robust baseline for assessing expected remediation effects induced by the application of the proposed SEDREMED technologies. Hereby, *in-situ* natural attenuation of polyaromatic compounds, albeit very low, has been proven. Lab microcosms demonstrated that the autochthonous microbial assemblages of the Bagnoli sediments, if properly stimulated, can degrade to a large extent PAHs in a relatively short time scale, even till their complete mineralization. This could be achieved by the supply of proper electron acceptors (i.e., oxygen) which can be generated by EKOGRID technology. The amendment of the Bio-Vase product from IDRABEL only slightly increased biodegradation of PAHs and might even limit PAH degradation in a primary period of application due to elevated oxygen consumption. On the other hand, Bio-Vase is assumed to adsorb/immobilise heavy metals, which has to be evaluated in upcoming tests.

More robust conclusions will be possible from currently running mesocosm experiments, where both technologies have been combined (cross-cutting Action B1). Most of the monitoring methods listed above will be used and further validated also in the upcoming Action B2 (field implementation of selected technologies).

Action B4 – Replicability and transferability roadmap (M6-M42)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
03/2022	03/2022	03/2025		Ongoing

Table 6 Status of Deliverables and Milestones – Action B4

Deliverables	Foreseen date	Status
Stakeholder and market analysis	09/2023	Ongoing
Replication and transfer plan	09/2024	Not elaborated yet
Business plan and IPR strategy	03/2025	Not elaborated yet
Milestones	**Foreseen date**	**Status**
List of stakeholders prepared	07/2023	Ongoing, scheduled on time
Business case fundamentals prepared for the *in-situ* remediation approach	01/2025	Not elaborated yet

Action Leader: NIS
Partners involved: ALL

At this project status, only planning of the action has been implemented, mostly with input from D1.
NISIDA organised two meetings with Technology providers (EKO and IDRA) to collect key information regarding the relevant stakeholder and market analysis for North Sea basin and Baltic Sea basin.
Nisida decided, following the divulgation event, to switch the analysis from single member states to sea basins. The redaction of the deliverable is ongoing and will be submitted in time at the end of September 2023. The sea-basins selected are:
1. Western Mediterennean sea-basin
2. North Sea basin
3. Baltic Sea basin

Action B5 – Creation and operation of the Mediterranean Remediation knowledge and innovation hub (MEDREHUB) (M25-M42)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
10/2023		03/2025		

Table 7 Status of Deliverables and Milestones – Action B5

Deliverables	Foreseen date	Status
Publication of MEDREHUB funding strategy and event program	01/2025	Not elaborated yet
Milestones	**Foreseen date**	**Status**
MEDREHUB set-up	12/2024	Out of reporting period
MEDREHUB Opening-day (Project's Final Conference)	03/2025	Out of reporting period

Action Leader: SZN
Partners involved: INV, NIS, UNIVPM

SZN and all partners involved in this action starts to formalise the plans for the after-life of the MEDREHUB, they are working on developing a Memorandum of Understanding with the other institutions that will be involved in the management of the MEDREHUB, in which the roles of each partner in the financing and functioning of this forum are clearly defined, with the following structure:

- Impact of MEDREHUB:

The creation of the MEDREHUB will ensure the continuation of the project, becoming a reference point for the environmental remediation and restoration sector in Italy and in the EU, generating promising results, new project ideas and leading a positive socio-environmental impact.

- Role of each partner for the success of MEDREHUB:

Continuation of action D1 will be ensured by the coordinator SZN through the specific dissemination events organized in MEDREHUB (action B5) at the end of the project (LIFE SEDREMED final conference) and in the 2 years following the end of the project (03/2027). The SZN will be assisted in the management of the hub and in the organisation of events by the local and national academic and research institutions (UNINA, UNISA, CNR). UNIVPM will also be a key actor in the continuation of B5 and D1 by directly participating in the proceedings of the MEDREHUB and by organising specific dissemination events in Ancona after the project ends. NISIDA will be one the protagonists in driving and managing the activities of MEDREHUB by assisting academic institutions and private companies in the preparation of project proposals and by supporting SZN in the organisation of conferences and seminars after the project ends. In the framework of action B5 and E2, NISIDA will also be responsible for the involvement of citizens in the observation and participation in the life project actions in order to make Bagnoli's population an important stakeholder of the project.
UNIVPM and ISO will lead further research and project design on environmental remediation technologies, by investigating potential replication and transferability opportunities in particular for the developed advanced monitoring plan. SZN together with other research and academic partners, and with the support of NIS will drive the design of new EU funded projects to finance the activities of the hub and to implement other innovative approaches in marine contaminated sites in Italy and in the Mediterranean area. Finally, NIS will lead citizens'

involvement and participation activities (through specific events and site visits), by promoting exchange between civil society and public authorities managing the site. INV has not charged costs on this action because their financial resources (coming from IT government) can be allocated only to actions strictly connected to handling, remediation and monitoring of sediments. However, they will still provide relevant support, when needed, and obviously participate in relevant events held in MEDREHUB during and after the project.

- MEDREHUB location:

The MEDREHUB will be hosted in one of the ex-industrial regenerated buildings managed by SZN, where soil remediation is currently ongoing, and is expected to end by 2023/2024.

- MEDREHUB thematic fields and activities:

The hub will be set up by the end of 2024 and organised around three thematic fields:

1) Environmental remediation technologies (UNIVPM and ISO lead);
2) Biodiversity restoration methodologies (SZN Lead);
3) Water and Wastewater treatment technologies (NIS Lead).

It will undertake the following activities in the after-life period:

- Develop a strategy and participate in pertinent EU calls, in collaboration with SZN's grant office.
- Plan and organise dissemination events until 03/2027, including 1 international conference per year, 2 technical workshops, 2 webinars and 1 civil society event (during 2026 dissemination will focus on LIFE SEDREMED final results and findings while in 2027 it will focus on innovative technologies and methodologies for biodiversity and ecosystem services restoration).
- Promote the active involvement of citizens, to integrate them in the ongoing remediation process in Bagnoli and in future management and protection activities of remediated areas (both terrestrial and marine)

- Sustainability

NISIDA will be one the protagonists in driving and managing the activities of MEDREHUB by assisting academic institutions and private companies in the preparation of project proposals and by supporting SZN in the organisation of conferences and seminars after the project ends. This activity will include the active collaboration with SZN and INV to propose a project to use funds dedicated to research & development in the "National Plan of Redevelopment and Resilience (PNRR)" based on the funding allocated by the EU to Italy through the "Next Generation EU" plan. Additionally, SZN together with other research and academic partners, and with the support of NISIDA will drive the design of new EU funded projects to finance the activities of the hub and to implement other innovative approaches in marine contaminated sites in Italy and in the Mediterranean area. One of the ideas under scrutiny is proposing a new LIFE Integrated Project focusing on management and decontamination of inland and coastal sediments, this project would integrate both new technological applications for decontamination and plans to stop pollution at source, in addition to promoting further developments in IT & EU policy and increasing stakeholder and citizens engagement in large decontamination activities. This last point is crucially important and will be a central aspect of the sustainability of the MEDREHUB, NISIDA lead citizens involvement and participation activities (through specific engagement events and site visits), by promoting exchange between civil society and public authorities managing the site with the objective to increase confidence in the institutions and develop the sense of belonging that has been dramatically lost in Bagnoli.

Action C1 – Monitoring and measuring of the LIFE project KPIs and remediation results (M1-M42)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
10/2021	11/2021	03/2025		Ongoing

Table 8 Status of Deliverables and Milestones – Action C1

Deliverables	Foreseen date	Status	Annex
Extract of the project data from the KPI webtool	07/2022	Done on time	**6.1.5**
KPI Webtool update and Intermediate assessment of Life Performance Indicators	03/2023	Update Kpi 2.3.7. see Chapter 7	**7.2**
KPI Webtool update and Final KPIs report	03/2025	Not elaborated yet	
Report on LCA/LCC analysis of implemented technologies	02/2025	Not elaborate yet	
Report on project's socio-economic impact	03/2025	Note elaborated yet	
Report on monitoring of KPIs, including update of the LIFE KPI table	03/2025	Not elaborated yet	
Milestones	**Foreseen date**	**Status**	
First validation of KPIs foreseen by LIFE SEDREMED project	03/2023	Done on 07/2022.	
LCA and LCC analysis completed	12/2024	Out of reporting period	
Final validation of KPIs foreseen by LIFE SEDREMED project	03/2025	Out of reporting period	
Final validation of KPIs foreseen by LIFE SEDREMED project	03/2025	Out of reporting period	

Action Leader: ISO
Partners involved: UNIVPM, SZN, NISIDA

The action will see the assessment of the environmental sustainability of the tested technologies, through LCA analysis carried out by UNIVPM. In particular, the environmental sustainability of the tested technologies will be compared to other reclamation options (e.g., dredging, transport, and disposal in confined site). In addition, a social LCA and a LCC will be performed.
The work carried out by UNIVPM in this first reporting period was focused on the definition of comparative scenarios (system boundaries, Figure 3), together with mass and energy balances, based on literature data (Table 9). This work is preparatory to the first LCA that will be run by the end of October 2023, and to the final LCA, social LCA and LCC that will be run with real data produced by project partners by December 2024.

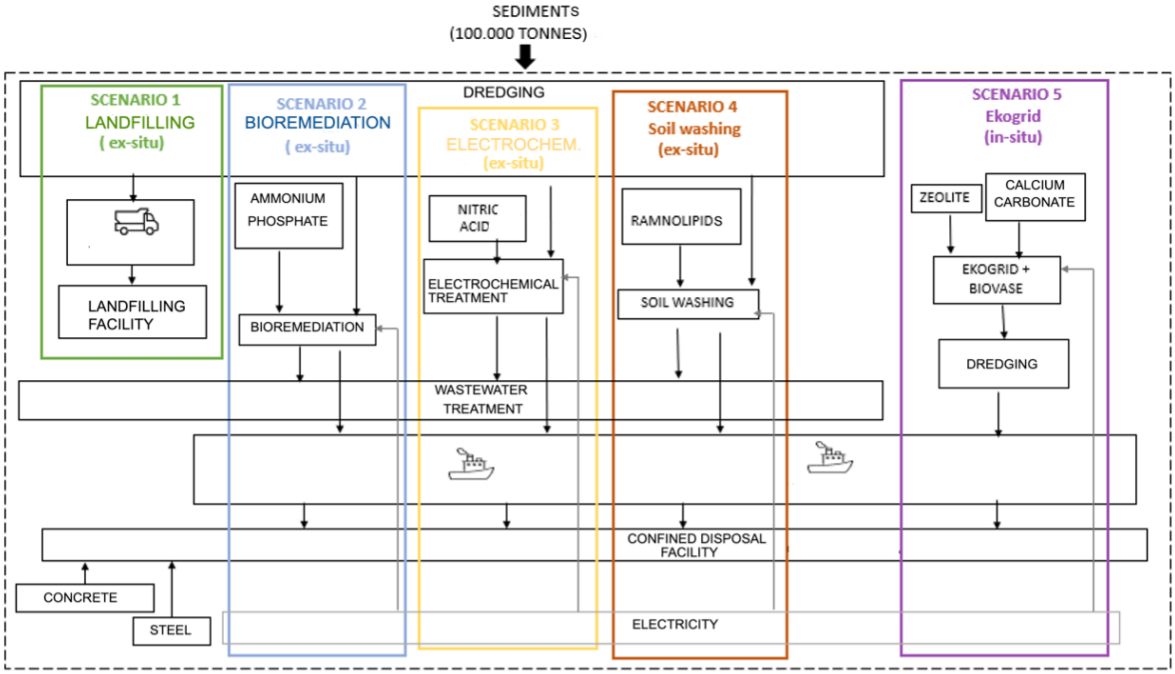

Figure 3 System boundaries

A quantity of sediment subjected to remediation equal to 100,000 tons has been chosen as the functional unit; this is considered as representative of the quantity of material with the highest level of contamination and hazard (i.e., falling in the quality class E).

Five possible scenarios have been identified for effective remediation, based on literature analysis. Among such scenarios, ex-situ and in-situ treatments are considered. In the first case, a dredging operation is needed to remove the contaminated sediments to the treatment/disposal site. The dredging system will be located on land, it will have an engine power of 287 KW, a load capacity of 250 cubic metres per hour and a consumption of 33 litres diesel per hour (Italdraghe-Dredging and pumping solution S.p.a.). After dredging, the contaminated sediment is sent to a landfill site for hazardous waste (scenario 1) or subjected to different ex situ remediation techniques (scenarios 2-4). Scenario 5 is based on the innovative LIFE SEDREMED treatment, it includes an *in-situ* treatment using the EKO technology combined with the IDRA one, and it has been supposed to reduce the present contamination and downgrade the material from quality class E to quality class D. Such treatment will allow the disposal in confined disposal facility (CDF), after dredging.

More specifically, scenario 1, after dredging, includes transportation using trucks with a capacity of 27.4 t, at a distance of approximately 9 km, to the nearest landfilling facility "3T Ambiente", where the contaminated sediment is disposed of as hazardous waste. Scenario 2 consists in the use of biostimulation, based on the addition of inorganic nutrients to favour the biodegradation of organic contaminants and the potential bioleaching of metals by the allochthonous microbial community; this will take place in a stirred bioreactor, installed onsite. Different ex situ biotreatment options were evaluated, among which the most suitable was the one described by Dell'Anno *et al.*, (2020). Scenario 3 is based on electrokinetic remediation in the presence of nitric acid in concentration 0.1M to maximise process efficiency (Ammami *et al.*, 2013). Scenario 4 envisages a soil washing technology (Lai *et al.*, 2009), with the addition of rhamnolipid biosurfactants, in quantities equal to 0.2%, to favour the solubility of the contaminants and facilitate their removal from the sediment itself. The 3

ex situ scenarios (Scenario 2 to 4) are supposed to reduce contamination levels, allowing the management of the treated sediments in CDF. Consequently, after the treatment, the sediment will be transported by boat (total load of 124 tons) from the Bagnoli area to the port of Naples. Moreover, for scenarios 2 to 4, the treatment of wastewater produced during the sediment remediation processes is also considered.

Table 9 Mass and energy balances (functional unit 100.000 tonnes contaminated sediments

<table>
<tr><td colspan="5"><u>Dredging</u>
(Common to all scenarios; Italdraghe-Dredging and pumping solution S.p.a)</td></tr>
<tr><td colspan="5">· Diesel 33.000 L -Sediment plus water: 250.000 m3</td></tr>
<tr><td></td><td colspan="4"><u>Realization of a confined disposal facility</u> (CDF)
(common to scenarios 2 to 5, Cappucci et al., 2019)</td></tr>
<tr><td></td><td colspan="4">· Concrete 34.000 t
· Steel 230 t
· For excavation: 6600 L diesel</td></tr>
<tr><td></td><td colspan="4"><u>Seawater transportation</u>
(common to scenarios 2 to 5)</td></tr>
<tr><td></td><td colspan="4">· Distance 11 km (to the CDF in Naples harbour);
· 800 return trips;
· Vessel capacity 124 t</td></tr>
<tr><td>Scenario 1
Dredging + <u>disposal in hazardous waste landfilling site</u></td><td>Scenario 2
Dredging + <u>on site bioremediation</u> + disposal in confined disposal facility (CDF) (Dell’Anno et al. 2020)</td><td>Scenario 3
Dredging + <u>on site electrochemical treatment</u> + disposal in CDF (Ammami et al., 2013)</td><td>Scenario 4
Dredging + <u>ex situ soil washing</u> + disposal in CDF (Lai et al. 2009)</td><td>Scenario 5
<u>In situ Ekogrid - Idrabel integrated</u> + dredging + disposal in CDF (Grace Project, 2018)</td></tr>
<tr><td>· distance 9 Km (landfilling facility “3T Ambiente”;
· 3700 return trips;
· truck capacity 27,4 t</td><td>· electricity 67.200.000 kWh
· ammonium phosphate 9.000 t
·wastewater to treat: 200.000 m3</td><td>· nitric acid 4.300 t
· electricity 4.700.000 kWh
· wastewater to treat : 330.000 m3</td><td>· electricity 3.000.000 Kwh
· wastewater to treat : 100.000 m3</td><td>· electricity 1.920.000 Kwh
· 0,36 tonnes zeolite
· 1,4 tonnes calcium carbonate</td></tr>
</table>

- Ex-ante socio-economic info for the Bagnoli Site of National Interest:

The history of Bagnoli is far from unique, similar environmental and socio-economic consequences can be found in many other Italian and European cities, in fact the extent of abandoned industrial areas in Italy accounts for 3% of its territory. The ex-ante situation is being developed and will include an analysis from 1990 (Dismissal of Bagnoli’s industrial site) to 2020 (development of project proposal). To understand the socio-economic situation of the Bagnoli district, in which the LIFE SEDREMED project is implemented an overview of the events that followed the closure and decommissioning of the industrial area has been compiled. In terms of numbers the unemployment figure is available from the last official analysis for the city of Naples that dates to 2011. The unemployment rate for the 10th municipality (Bagnoli and Fuorigrotta is 22,76% while if we isolate only the Bagnoli district the rate reaches 25,2%

(15% higher than EU average in the same year). For presence of economic activities, despite Bagnoli having 2,46% of Naples total population in working age, it has only 1,97% of the total businesses of the city and 1,81% of the total employees employed in private businesses. These figures clearly outline the dynamic of socio-economic deterioration in the city of Naples and particularly in the Bagnoli district. Finally, the worst consequence of this process is emigration with over 17.000 people leaving the province of Naples only in 2021.

The LIFE SEDREMED project is thus implemented in an area where immediate action is needed to ameliorate the socio-economic conditions. The social LCA developed and run by UNIVPM will highlight how the project activities and the technologies developed will help promote socio-economic development in the area.

Action D1 – Communication Dissemination and Exploitation plan (M1-M42)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
10/2021	11/2021	03/2025		Ongoing

Table 10 Status of Deliverables and Milestones – Action D1

Deliverables	Foreseen date	Status	Annex
LIFE SEDREMED website	01/2022	Completed with Delay 06/2022.	
1st communication, dissemination and exploitation plan	03/2022	Ready on time and provided during the 1st visit (expected with the MTR).	6.1.7
Intermediate communication, dissemination and exploitation plan	08/2023	Ongoing	
Final communication, dissemination and exploitation plan	09/2024	Not elaborated yet	
Layman's Report	01/2025	Not elaborated yet	
Notice board	03/2025	Installed earlier (04/2023)	
Milestones	**Foreseen date**	**Status**	
50 stakeholders engaged through dissemination events	01/2024	Out of reporting period	
Synergies established with 2 LIFE or EU-funded projects	10/2024	Out of reporting period	
20000 users engaged on the project's website and social channels	12/2024	Out of reporting period	

Action Leader: NIS
Partners involved: ALL

The 1s version of the communication, dissemination and exploitation plan (CDEP) is done (04/2022). The preparation of the intermediate CDEP is ongoing and will be delivered in time by the end of August 2023

- Logo and website:

The company in charge of the graphic identity and website development has been selected on 25/03 (FUTUREVOX) and delivered the products (graphic identity and templates). A first draft of the graphic identity and website wireframe were presented to the partners at the 1st visit. The related tools (templates word and ppt) are in place. Website shared with partners for feedback and published in 06/2022 at https://life-sedremed.eu/.

- Newsletter:
The launch of newsletter was sent after the first divulgation event in Brussels on 14 of February and the firs newsletter was sent on 8 of April 2023. The newsletter was sent to 148 recipients with and obtained an engagement rate of 35%.
The divulgation team is working to further increase the subscriptions to 200 people before sending the next newsletter by the end of September in order to include articles concerning participation at Sednet conference and on-site implementation of the technologies.
- Brochures and roll-up:
The brochures (600 in Italian and 500 in English) containing all the project information were produced and sent to all partners in January 2023 (Annex 6.1.7.1).

A second Brochure containing updated project information, such as *in-situ* implementation set-up and final decontamination/financial results will be produced at the end of 2024 to be distributed at the final conference.
n.10 roll-up were produced and sent to all partners in January 2023. SZN INV and Nisida have two different Roll-up, one with all the project details and one only containing general partnership information (all printed materials are available in the google folder shared with all partners and monitoring).
All printed materials are annexed in Annex 6.1.7.2.
- Press releases.
The first press release announcing the project to the media was published on 4th October 2022. (https://life-sedremed.eu/221003_press_release_bagnoli_sedremed/)
The second press release was published on March 13th and included news about the first divulgation event and project progress.
- Project Videos.
1) NCP Belgium has produced together with IDRA a video presenting the company and the project. The video shows lab activities ongoing in Belgium and it will be used to present the partner on our social media channels.
2) Canale Energia made an interview of project coordinator and project manager and it was published on social media channels.
3) A video from INV showing an area view of the implementation site was published on the website and included in the newsletter.
4) RAI 1 produced an interview with SZN in Bagnoli, in which the project coordinator explained the topic and the progress of the project. It is published on websites and social media.
5) Nisida will produce 2 project videos, the firs one will be an animation representing the on-site implementation of the technologies and the second one will be a short documentary of 20 minutes that will include interviews already made at the first divulgation event and action during on site implementation.
- Notice boards.
The first notice board has been installed (see Figure 4) in front of Invitalia offices at the entrance of the contaminated site and on one of the busiest streets of Bagnoli (Via Diocleziano). The notice board includes information about project objectives and activities, a map of the implementation site, key data, description of the partnership and a QR code to access the digital communication channels. A dedicated social media post was published on our three platforms (Linkedin, Twitter, Facebook) and had an excellent engagement rate.

Figure 4 1st Notice board installed near the entrance of the contaminated site

A second notice board will be installed next to the implementation area.

- Social media

An editorial plan (posts calendar) was developed.

The first post on social media was launched after the press release at the beginning of October, followed by other social posts.

They were shared via Facebook, Twitter and LinkedIn, with good content resharing and divulgation. We have chosen to communicate in English on Twitter and Linkedin and in Italian on Facebook.

To this day we have reached the following numbers:

- 331 followers on Linkedin (21 posts)
- 96 followers on Twitter (27 tweets)
- 57 followers on Facebook (21 posts)

Concerning Facebook, we made the choice to publish news in Italian in order to dedicate this channel to local citizens. However, since the communication with the local community is delicate (Bagnoli has been waiting for decontamination for the past 30 years with several projects that failed and judiciary investigations involved), we are developing a strategy that also includes a risk management plan in order to moderate negative comments. After the publishing of the first concrete action news ("Field work starts in Bagnoli") we will start publishing the page on local citizens Facebook groups in order to increase followers and engagement on the page)

- Project events.

1- The first general assembly was held at the beginning of February 2023 in Wavre, Belgium at IDRABEL premises. The first divulgation event was held just after the GA in the format of an expert roundtable held in the EU district in Brussels. The event foresaw the interventions from the European Commission (DG ENV and CINEA), the Italian and Finnish Permanent Representation to the EU, LIFE SEDREMED Project Coordinator/Technology Providers, LIFE Sure Project Coordinator, members of LIFE NARMENA and LIFE BELINI, the Swedish geotechnical institute and the Italian ministry of Environment and Energy Security).

2- International events. LIDE SEDREMED has been selected to participate with a poster and an oral presentation at the next SEDNET conference. Other events have been selected by the consortium and the participation of the project is being planned (e.g., Ecomondo-IT, Remtech-IT, Pollutech-FR, Genera-ES, IFAT-DE).

We have sent a workshop proposal for the European Maritime Days to be held in Brest (FR) on 23-24 may 2023, unfortunately our proposal was not accepted, however we will try again next year.

- Demonstration visits.

Expected half-way through the project and at the end of action B2, to involve high-schools, universities students, local NGOs and citizens.

- Meeting with civil society.

Already at the proposal stage, the consortium contacted various local associations (Associazione MADRE and LEGAMBIENTE). A first meeting with the local citizen association (Osservatorio popolare per la bonifica di Bagnoli) was held to inform the citizens about the project timeline and actions. Other meetings will be organised when on site implementation will be started.

- Stakeholders engagement.

The first divulgation even was used to engage with related life projects and other key stakeholders: European Commission (DG ENV and CINEA), the Italian and Finnish Permanent Representation to the EU, LIFE Sure Project Coordinator, members of LIFE NARMENA and LIFE BELINI, the Swedish geotechnical institute and the Italian ministry of Environment and Energy Security)

- Networking:

Several direct contacts were made with different LIFE projects over the past months. Additionally, the divulgation event in Brussels saw the physical participation of 3 LIFE projects. To structure and manage the relationship a dedicated excel file has been created to map related LIFE, HORIZON and INTERREG projects.

LIFE REMEDIA Project – Meeting held with SZN at the end of October 2022

LIFE SEKRET and LIFE MAR PICCOLO – Joint online event in October 2022 together with the Italian Environment Ministry

LIFE GREEN SITE - Dr. Zanotto from the company 2A Group was contacted in view of our ongoing work for SLCA and LCC, he informed us that he worked at the port authority of Venice for the project ECOREMED and sent us the final report of the project.

LIFE MARINAPLAN PLUS – The company Trevi Group was contacted in view of the organization of the expert roundtable, they answered that they have not gone forward with the development of the technology.

LIFE SURE, LIFE NARMENA, LIFE BELINI – Participated in presence and with presentations to the expert roundtable organized in Brussels in February 2023.

The technological developments obtained by LIFE SURE and LIFE NARMENA could be useful for our partner INVITALIA in sediment management and decontamination projects.

Below you'll find a screenshot of the EU project mapping we are developing over the course of the project (other sheets include HORIZON and INTERREG projects).

LIFE PROJECT (YEAR)	DESCRIPTION	ENGAGED	SINERGY LEVEL	POTENTIAL SINERGIES	WEBSITE	SOCIAL	COORDINATOR	PROJECT MANAGER	E-MAIL	PHONE N°	LAYMAN REPORT
Life4MarPiccolo (2014)	Membrane-based purification pilot plant to restore a 2100 m2 section of the Mar Piccolo coastal basin (interested by steelwork and petrochemical pollution)	YES	HIGH	The contamination of Mar Piccolo is very similar to Bagnoli, information could be exchanged on technologies implementations and challenges to tackle the pollution load	http://www.lifemarpiccolo.it/	https://www.facebook.com/life4marpiccolo	ENEA (IT)	Gaetano Perrotta	gaetano.perrotta@enea.it info@lifemarpiccolo.it	/	http://www.lifemarpiccolo.it/images/download/Life4MarPiccolo_LaymansReport_ENG_marzo22_web.pdf
SEKRET LIfe (2012)	Treatment of contaminated dredged sediment with electrokinetic remediation (EKR). The project will construct an EKR demonstration plant in the Port of Livorno to treat approximately 150 m3 of dredged sediment.	YES	HIGH	The application of electrokinetics to contaminated sediments could provide our project with info on risks and issues adressed during the project implementation, portentially innovation developed ex-situ could be useful for our in-situ approach	http://lifesekret.com/	https://www.facebook.com/profile.php?id=100064253316694&ref=nf	UNIVERSITA DI PISA (IT)	Renato Iannelli	r.iannelli@ing.unipi.it	/	http://lifesekret.com/wp-content/uploads/2017/10/Laymans-Report-SEKRET-ENG.pdf
LIFE SURE (2015)	Demonstrate a cost-effective and ecologically sustainable process for retrieving and recycling sediments in shallow eutrophic waters.	YES	HIGH	The innovation from this project could be combined with a pre-treatment with the sedimred technique, this would allow a safer and cheaper dredging intervention	https://lifesure.kalmar.se/	https://www.facebook.com/lifesurekalmar/	MUNICIPALITY OF KALMAR (SE)	Renate Foks	renate.foks@kalmar.se	/	https://lifesure.kalmar.se/download/18.518987db1816490cb11760/1655981279810/Slutrapport_LifeShore_Webb.pdf
LIFE GREENSITE (2010)	Demonstrate the effectiveness of innovative technologies for the reclamation of sediments from the excavation of the canals located in the industrial area of Porto Marghera, Venice. Set up compact technologies for the quick decontamination of marine and fluvial sediments contaminated by hydrocarbons and other organic substances (PCBs and pesticides among others) which and a negative impact on both human health and ecosystems in waterside areas.	YES	HIGH	Information could be exchanged on technologies implementations and challenges to tackle the pollution load	https://webgate.ec.europa.eu/life/public/Website/project/details/3365	NOT WORKING - http://www.green-site.it/	Azienda Lavori Lagunari Escavo Smaltimenti (IT) - AZIENDA PROB CHIUSA - Chiedere info alla commissione per deliverables	Guerrino Cravin	g.cravin@alles.it	/	Only final report availble offline
LIFE NARMENA (2018)	Removing metal pollutants from watercourses and floodplains through nature-based remediation. Its objectives are to demonstrate bacteria-assisted phytoremediation and constructed wetland techniques in Flemish watercourses polluted by chromium, arsenic cadmium and radium.	YES	MEDIUM	There could be interest in exchanging informations on the microorganisms used for decontamination and on the mobility of heavy metals	https://ovam-english.vlaanderen.be/web/narmena/home	https://www.linkedin.com/groups/13890217/	OVAM (Public Waste Agency of Flanders) (BE)	Froukje KUIJK	fkuijk@ovam.be	0032 15 284 284	DOWNLOAD AT BOTTOM OF THE PAGE: https://webgate.ec.europa.eu/life/publicWebsite/project/details/3365
LIFE AGRISED (2017)	Treatment and reuse of dredged sediment to produce innovative technosols usable for the reconstitution of degraded land and brownfields and as innovative growing media for plant nursery	NO	LOW	In cases of pre-treament of sediments with Sedremed technique and subsequent dredging the reuse possibilities developed by the project could be of interest.	http://www.lifeagrised.com/en/	https://www.facebook.com/lifeagrised https://twitter.com/lifeagrised	AGRI VIVAI SRL (IT)	Stefano Lucchetti	stefano.lucchetti@agrivivai.it	/	http://www.lifeagrised.com/wp-content/uploads/2022/06/LAYMAN-REPORT-ENG_LR.pdf
LIFE CLEANSED (2012)	Treatment and reuse of dredged river sediments into valuable materials for plant nurseries and for road construction.	YES	LOW	In cases of pre-treament of sediments with Sedremed technique and subsequent dredging the reuse possibilities developed by the project could be of interest	http://www.lifecleansed.com	https://www.facebook.com/profile.php?id=100079861950506	CNR ISE (IT)	Graziana Masciandaro	grazia.masciandaro@ise.cnr.it	/	http://www.lifecleansed.com/wp-content/uploads/2016/06/Laymans-Report-CLEANSED1.pdf
LIFE MARINAPLAN PLUS (2015)	Innovative and reliable technology at industrial scale for seabed maintenance and the removal of sediment, to guarantee navigability at a port inlet without the need for dredging operations.	YES	LOW	In case of application on polluted port sediments it could be useful to applyh the sedremed technique before sediment evacuation in the open-sea	https://www.lifemarinaplanplus.eu/en/	https://www.youtube.com/@marinaplanplus273	TREVI SPA (IT)	IF OF INTEREST GET IN CONTACT WITH PLANT ENGENERING	/	/	https://www.lifemarinaplanplus.eu/downloads/3171/83/D1.7%20Laymans%20report%20v01.pdf
LIFE ECOREMED (2011)	Define an operative protocol for agriculture-based bioremediation of contaminated agricultural soils in the "Litorale Domitio-Agro Aversano" NIPS;	YES	LOW	Our coordinator coul gather feedback from colleagues at the University of Naples since this project was implemented in a highly polluted area in Campania region	https://webgate.ec.europa.eu/life/public/Website/project/details/3550	NOT WORKING - http://ecoremed.it/en	UNIVERSITY OF NAPLES FEDERICO II - CIRAM (IT)	Massimo Fagnano	fagnano@unina.it	/	DOWNLOAD AT BOTTOM OF THE PAGE: https://webgate.ec.europa.eu/life/publicWebsite/project/details/3550
LIFE BELINI	The project is focused on the basins of the Zenne, Dyle and Demer rivers. These catchment areas are representative of the entire Scheldt district. All water management problems that are typical for the catchment area of the Scheldt are also present here: stress from the urban area, erosion, stress from the agricultural sector, hydro-morphological changes, flooding risks, groundwater contamination, etc. A number of actions aim to reduce			Important information on how to integrate sediment management in river basin management plans and what actions were undertaken when confronted to the presence of contaminated sediments in non-navigable waterways such as in Tournai.							

Figure 5 Screenshot of the EU project networking mapping

NISIDA and SZN participated in the pitching Meet & Share training session (7/02/2023) to have the important skill on HOW to prepare, at short notice, a custom-pitch to your target group. At the end of meeting, NIS produced a sharp elevator pitch (Figure 6), which can then be developed into a document, be on promo materials or even go out in emails.

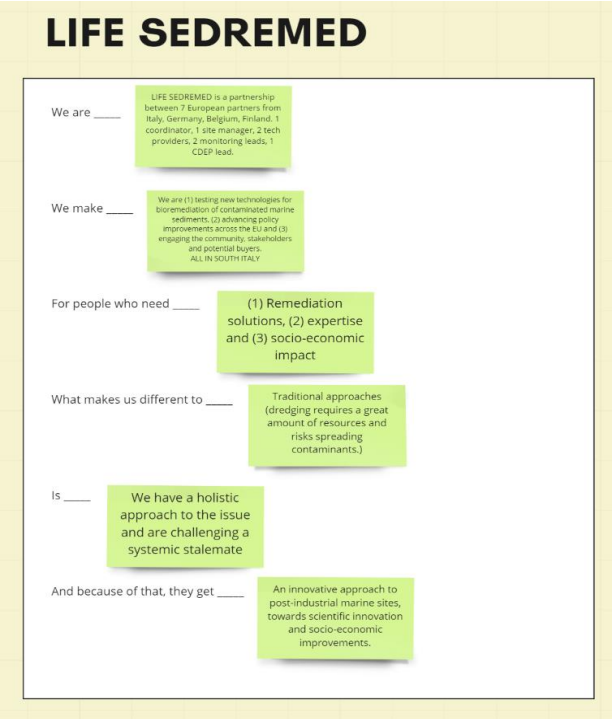

Figure 6 LIFE SEDREMED pitch

Action E1 – Project management (M1-M42)

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
10/2021	10/2021	03/2025		Ongoing

Table 11 Status of Deliverables and Milestones – Action E1

Deliverables	Foreseen date	Status	Annex
Project management Plan	01/2022	Done on time and provided in the 1st visit (expected with the MTR).	6.1.8
Interim project report	09/2023	Foreseen on time	
Final project report	03/2025	Out of reporting period	
Milestones	**Foreseen date**	**Status**	
Consortium agreement signed	01/2022	Achieved on 03/2022.	

Action Leader: SZN
Partners involved: NIS, ALL

The project KOM was held in 12/2021 and since then the team has met on an ad-hoc basis. The partnership agreement was signed and the Project Management Plan was prepared (Annex 5.1 and 6.1.8)
Project management structure was set up and is as foreseen in the proposal:
- Project Coordinator (PC): Donatella de Pascale, supported by a temporary researcher.
SZN launched the procedure to hire a project manager in early 2022 but the call had to be re-issued since the candidates were deemed unacceptable and another tender was issued. The 2nd procedure was completed and the PM selected by mid-07/2022 - Chiara Melchiorre.
- Project Management Team (PMT), composed by the PC and SZN's Legal and Finance Officer (LFO), Grant Innovation Office (GIO) and communication department.
- Steering Committee (SC): composed of the PC, the Project Manager and SEDREMED leaders: technical (EKO), innovation and dissemination (NIS), monitoring (UMIVPM).
- General Assembly (GA): chaired by the PC, and comprising one designated representative per partner and those assigned responsibility for specific areas (e.g. communications and dissemination, public engagement, gender aspects). They will meet annually to oversee the strategic orientation of the project.
- Scientific Advisory Board (SAB)
A Scientific Advisory Board of external scientists serves as an external advisor to the project, assisting the PMT by providing advice and perspective. The SAB will assess progress of the project, participate in risk assessment and provide advice to the decision-making and on new directions and opportunities for innovation and promotion of SEDREMED results, as well as for interacting with relevant national and European projects and other stakeholder groups. The members of the Advisory Board have been identified and will be nominated by the coordinator, after discussion with the Scientific Committee. The PMT committee decides to nominate the coordinator of LIFE MySOIL and the coordinator of LIFE Narmena, who accepted and signed the SAB agreement. Whitin their respective projects, they have great experience in the developing technology for

remediation of sediments and soil and therefore, they could contribute providing very useful advice in SEDREMED project. Moreover, the committee decided to nominate also Mr Johan Persson (Kalmar Municipality, SE) and Mr Frank Schmieder (Linnaeus University, SE), as two representatives of the LIFE Sure project who were invited to the 1st Divulgation event in Bruxelles to share and identify solutions for the management of contaminated sediments. We are waiting their response. Their experience could be critical in advice SEDREMED project as they developed a pilot dredging machine able to minimise the resuspension of sediment particles during the removal process. This is a key aspect to ensure environmental safety in case that even after in-situ remediation, the sediments removal still is necessary. SAB members will have access to all project reports for critical assessment of project progress, and they will be invited to participate in the next annual meeting, which will be held in Italy by the end of this year, and the other 2 scheduled for the year 2024 in Finland and the final meeting in Rome in order to contribute actively in open scientific discussions between all partners of SEDREMED project.

A Dropbox folder was created to store all project documents (with only SZN coordinator PM and GIO having access to the folder). A Google Drive LIFE SEDREMED is created and shared with all consortium and monitoring, in which all documents are shared and used to save the progress of the different tasks and as a working platform. The consortium has held monthly (or as needed) virtual meetings, with an agenda and invitation by Teams in advance and minutes taken and saved in Drive dedicated folder (starting from PM enrolment). The consortium meetings are summarized in Table 1.

Formal description of perceived risks and planned contingency measures relating to all SEDREMED activities (Risk and Contingency Plan) was prepared and shared with all partners (Annex 6.1.9). It will be updated throughout the project if necessary.

Table 12 Dates and meetings held within LIFE SEDREMED project

Date	**Purpose of the meeting**	**Partners involved**
1-2 /12/2021	Kick-off meeting	All consortium
04/2022	1st monitoring visit	External monitor, All consortium
7/10/2022	Follow-up meeting: Action B1	IDRA - ISO -UNIVPM - SZN
13/12/2022	Follow-up meeting: Action C1	ISO - UNIVPM -SZN- NIS
14/12/2022	Follow-up meeting: Action B1	IDRA - SZN - EKO
18/01/2023	Follow-up meeting: Action B1	IDRA - EKO-ISO-UNIVPM- SZN
7-10/02/2023	1st Annual meeting + 2nd monitoring visit	External monitoring, All consortium
23/02/2023	Folllow -up meeting: Action C1	ISO - UNIVPM -SZN - NIS
01/03/2023	Folllow -up meeting: Action C1	SZN - UNIVPM - ISO
11/04/2023	Follow-up meeting: Action B2	SZN - UNIVPM -ISO - IDRA
26/04/2023	Specific meeting in situ implementation logistics: Action B2	SZN - INV
02/05/2023	Specific meeting mesocosm set-up: Action B1	SZN-ISO-UNIVPM-EKO-IDRA-UNISALENTO
09/05/2023	Specific meeting meio and macro fauna: Action B3	UNISALENTO - SZN
17/05/2023	Specific meeting sampling meio and macrofauna: Action B3	SZN - UNISALENTO - UNIVPM
18/05/2023	Follow up meeting: Action C1	INV - SZN - UNIVPM
26/05/2023	Follow up meeting: Action D1	SZN - NIS
07/06/2023	Technical Meeting: Action B3/C1	UNIVPM - SZN - ISO

21/06/2023	Specific meeting sampling macro fauna: Action B3	UNISALENTO - SZN

Action E2 – After-LIFE plan

Foreseen start-date	Actual start-date	Foreseen end-date	Actual end-date	Status
10/2024		03/2025		Not started yet

Table 13 Status of Deliverables and Milestones – Action E2

Deliverables	Foreseen date	Status
After-LIFE plan	02/2025	Not elaborated yet
Milestones	**Foreseen date**	**Status**
Collection of all deliverables and results of the project connected with its continuation	01/2025	Out of reporting period

Action Leader: SZN
Partners involved: NIS

The activities related to the After-LIFE plan will start by the first results achieved from *in-situ* monitoring activities (Action B3) and will include:
1st section (Actions: B2, B3, B4, C1):
- Project objectives, methodologies and results
- Social, economic and long-term benefits
- Sustainability, demonstration value and potential for replication and transfer
- Findings to update EU and IT legislation on sediment decontamination and management
- Simplified results of LCA and LCC
- Business plan and business strategies (licensing, geographical exclusivity etc.)

2nd section (B5, D1):
- Overview of dissemination activities and results
- Analysis of stakeholders involved and to be involved
- Description of synergies established with other LIFE and H2020 projects
- Strategy for civil society involvement in MEDREHUB activities and for interaction with INV
- Funding strategy for MEDREHUB
- Event program for MEDREHUB until 2027, including one international conference per year, two technical workshops per year, two webinars per year and one civil society meeting per year. Additionally, in the course of 2026 UNIVPM will organise an After-LIFE dissemination event.

6.2 Main deviations, problems and corrective actions implemented

1) Action A1:

The two sampling Areas initially selected (Areas 20/30 and 63/72 from ABBACO project) were modified as they present some logistical difficulties (e.g., no electricity supply for EKO's equipment).

The new two sampling Areas selected are:

(i) **Test field L** (Lower contamination; Area 70 from ABBACO, Città della Scienza/ Circolo Ilva (Sediment Class: C-D).
(ii) **Test field H** (Higher contamination, Areas 60/61 from ABBACO, located next to the South pier in. front of the "colmata" (Sediment Class: D-E).

2) Action B1:

Mesocosm activities were expected to take place in dedicated mesocosms at the SZN facility. After several technical meetings, all partners involved in this action decided to move all mesocosm activity at IDRABEL premises, in order to facilitate technology providers, the logistics to optimize the adaptation of their technology.
The most important deviation is related to the delay in the start of mesocosm activities as IDRA and EKO faced some technical problems in developing and adapting their technologies. After several meetings in Brussels the problems were solved and the pilot was set up, but this caused a short delay to the project, the pilot technology and the execution of the first mesocosm experiment started with a few months delay, hence the **deliverable B1.1 – *Ex-situ* bioremediation and prototype implementation** was achieved with 3 months delay. This delay contributed to the consortium's decision to postpone the interim report to June 2023 (find the mid-term postponed request letter to PA in Annex 5.4)

3) Action B2:

The *in-situ* remediation area was initially planned to be extended beyond 20m X 20m where the installation of 25 electrodes spaced 5m each other was foreseen. After several technical meetings, all partners agreed to reduce the treatment area to 10m x 10m with the installation of 9 electrodes per site (18 electrodes in total) spaced 5m, in order to manage with the logistical conditions of the installation, to increase the degree of success of the experiments and return to project costs. The readjustment of the work plan caused a slight delay (2 months) in the **deliverable B2.1 – Detailed work plan of the activities to be implemented**. A drafted Deliverable is now ready and it will be updated until the installation foreseen in October 2023.

6.3 Evaluation of Project Implementation

- The applied methodology was successful in keeping all partners actively involved in the project, working hard and cooperating to find solutions to the problems and issues that arose during the project actions. All partners are committed to achieving the project objectives and have a very positive and supportive attitude, despite an initial lack of communication with some partners. Many of the objectives foreseen in the proposal have already been achieved and all the results expected to be available at this stage have

been produced and are presented as annexes to this mid-term report. Table 14 presents the objectives, expected results and evaluation of each action up to March 2023.

Table 14 Description of objectives, expected results and evaluation of each action

Action	Foreseen in the revised proposal	Achieved	Evaluation
A1	**Objectives:** Uptake of characterization results to develop a technology/treatment train for the bioremediation of contaminated sediments **Expected results:** During this action the detailed sampling points and *in-situ* implementation areas will be selected	YES	This action has been successfully executed. Milestone has been achieved and deliverable elaborated.
A2	**Objectives:** Achieve all necessary procurements for sampling activities and *in-situ* technology installation in the selected area. **Expected results:** Partners will comply with DLgs 152/2006 (Italian law for environmental authorization) and with the INV (managing authority of the Bagnoli area and Partner of SEDREMED) rules for the access to the selected areas, collection of samples and for the *in-situ* application of remediation approaches. For all the necessary procurements the partners will follow green public procurement, the general rule of best value for money and their internal procedures.	YES	This action has been successfully executed. A document describing the tasks needed to have all authorisations was provided in the 1st visit and all authorisations have been obtained. Milestone has been achieved and deliverable elaborated with short delay.
B1	**Objectives:** Run mesocosm trials at prototype scale to ensure adaptation of technologies to the marine sediment matrix and maximum remediation efficiency during *in-situ* treatment. **Expected results:** Implementation and experimental parameter optimization of IDRA-EKO technologies in mesocosm. Run	Ongoing	The pilot is ready and was implemented in mesocosms at IDRA premises. Main issue was in implementing the two technologies. EKO and IDRA worked hard to solve it and in optimising system conditions. Tests on real sediments started with

	monitoring experiments related to B3 action.		short delay, the first monitoring results (Run1-3) were achieved in August 2023. Optimization of the experimental design for the next run 4-6 mesocosm experiments is underway
B2	**<u>Objectives:</u>** - *in-situ* electrokinetic system installation (EKO) to improve bioremediation capacity and to provide oxygen through water electrolysis for the oxygenation of biofixed micro-organisms (IDRA) that will be applied on sediments using metal rods. **<u>Expected results</u>:** - Remediate 2ha and 40000m3 of marine contaminated sediments to comply with EU (2000/60/EC, 2008/56/EC, 2008/105/EC) and IT Legislation (DM 56/2009). - Demonstrate the synergy of the proposed actions with the existing decontamination plan, acting on total sediment decontamination and reducing pollutant concentrations prior to eventual dredging interventions, reducing environmental risks and lowering sediment handling costs (from 150 to around 25€ per m3) (in compliance with DM 173/2016)	Ongoing	The experimental design has been established. EKO has engaged DST to carry out the installation work by the end of October
B3	**<u>Objectives:</u>** - Develop a detailed technology transfer manual and business plan to promote its replication and close to market uptake in other contaminated coastal areas around Europe. - Compare efficiency between 2 areas that have different levels of contamination through the use of advanced monitoring tools **<u>Expected results</u>:** - Remediation ranges of 60-80% are expected for organic pollutants.	Ongoing	

	- Remediation of toxic metals, fixation rates of 50-80% - Improve ecosystem services (ES) in the site linked to the enhanced environmental status of the area.		
B4	**Objectives:** - Develop a market and key stakeholder analysis. - Develop an IPR strategy and detailed business plan. **Expected results:** - Development of a detailed technology transfer manual and business plan to promote its replication and close to market uptake in other contaminated coastal areas around Europe. - Project Up-scaling: Italian and European replication within 5 years after project end.	Ongoing	This action is a close link to Action D1 (for the engagement of stakeholders). Nisida changed the MSs approach from single-MSs to sea-basins. The analysis could be more efficient by focusing on 1.Western Mediterranean sea-basin 2. North Sea basin 3. Baltic Sea basin
B5	**Objectives:** Creation and operation of Mediterranean Remediation Knowledge and Innovation hub (MEDREHUB) focusing on environmental bioremediation technologies. **Expected results:** The MEDREHUB will facilitate the continuation of the project activities and promote further research, design and implementation of innovative remediation technologies for the decontamination of Bagnoli and other polluted sites around Europe and the Mediterranean Sea.	Not started yet	
C1	**Objectives:** Monitoring and measuring of the LIFE project key performance indicators and remediation results. **Expected results**: - KPIs defined and uploaded to the web-tool.	Ongoing	This action is ongoing. The 1st snapshot of the KPIs was uploaded in July 2022 and was verified by CINEA. - About LCA, mainly preparatory activities

	- Revision of KPIs attached with the mid-term report - Final assessment of KPIs attached to the final report. - Life cycle assessment (LCA) elaborated - Life cycle costing (LCC) study elaborated. - Socio-economic impact of the technologies (*ex-situ* and *in-situ*) elaborated in connection with Action B1 and B2 and considering results from Action B3.		have been implemented so far, including: • Literature analysis • Definition of comparative scenarios. - Environmental and social LCA - List of indicators to monitor the project impact was elaborated.
D1	**Objectives:** - Communicate and disseminate the results obtained - develop an exploitation plan **Expected results:** - Communication strategy and dissemination plan report submitted. - Logo created. - Project website created. - Brochures printed. - Notice boards and rollups printed and installed. - Press release sent. - 5 technical dissemination events during the project (in 3 different MS). - Presentation of results in at least 3 external international events by the end of the project. - 2 demonstration visits during and after implementation actions - 1 meeting dedicated to civil society representatives - Actively engage at least 15 relevant stakeholders during the project (additional 15 in the two years after the project ends). - Social networks: Facebook, Linkedin, Twitter. - Newsletter every 6 months - 2 project video updates to be uploaded on the web and published	Ongoing	This action is being executed according to the proposed schedule. Deliverables are elaborated according to the project and attached in this report. LIFE SEDREMED has been represented in several networking events. The first Divulgation event was successfully done in Brussels in Feb 2023. Social networking accounts are active.

	- A final professional video-cut containing the project story in brief and a reportage from the plant setup (short documentary - 20/25 minutes) - A Layman Report for the wide non-technical audience		
E1	**Objectives:** Effective project management and monitoring throughout the project **Expected results:** - Accomplishment of the project objectives - Effective communication with NEEMO and CINEA - Kick-off meeting and General assembly meetings performed - Steering committee nominated - Advisory Board Meetings performed - Mid-term report, progress report, and final reports submitted	Ongoing	This action is on track. The KOM and 1st GA meetings were done in Naples on December 2021 and in Brussels on February 2023 respectively. - Advisory board was individuated and nominated. - progress and mid- term reports were delivered on time. - Risks and contingency plan were elaborated and constantly up-dated.
E2	**Objectives:** Elaborate the after Life plan. **Expected results:** - Continuation of actions B2, B3, B4 and C1 and the - Continuation of action B5 and D1. - Provide funding strategy for MEDREHUB with a clear dissemination program until 03/2027.	Not started yet	

- To date, the main visible results are the completion of all the preparatory actions (A1 and A2) which led to the achievement of the objectives foreseen in action B1: i) the successful first sampling campaign of surface sediments for the building of mesocosms and the first coring sampling campaign for the stratified analysis of organic pollutants and toxic metals in Bagnoli sediments at time zero; ii) the successful implementation

of two technologies (EKO – IDRA) in mesocosms and the start of 3 *ex-situ* experiments simultaneously (Action B1). The first experiment in mesocosm (*ex-situ*) consists in exposing the Bagnoli sediments to both technologies (EKO – IDRA). The second experiment consists in the exposure of the sediments to only EKO technology and the third no technology was installed in the mesocosm and it will be taken as control. The first organic pollutants and toxic metal monitoring results from *ex-situ* experiments (Run1-3) did not produce significant results, the experimental design is now being optimized for upcoming experiments and mesocosms (Run4-6). The detailed implementation plan of the *in-situ* technology is now ready (Deliverable B2.1in writing) and all partners involved in this action are going to prepare logistics to carry out the installation on time (by the end of October). Results about in field implementation will be visible after 3 months from the start of *in-situ* experiments. The results obtained by now regarding monitoring activity are summarized in Annex 6.1.6. The results obtained by now regarding dissemination activity are reported in Paragraph 6.1 Action D1 section.

- **Policy impact**

  The expert roundtable held in Brussels at the beginning of February was the perfect occasion to highlight the room for improvement of national, regional (sea-basin coordination) and EU legislation on sediment management and particularly on contaminated sediment management. The discussion held during the roundtable and the conclusion of LIFE SEDREMED can be accessed in our dedicated article on our website. We report here the conclusion of the article:

  To conclude this article provides a brief summary of the current situation and a potential solution to the lack of uniformity in sediment management across the EU.

  As stated by the experts, Member States require flexibility in analysing the site-specific situations and take into account factors – including area destination, specific pollutants, and financial expenses – that cannot be set in European legislation. However, in view of the discussion, LIFE Sedremed partners consider as useful the continuation of the inter-institutional debate to evaluate the definition of sediment-specific Environmental Quality Standards (EQS) at the European level in order to align all Member States on a common benchmark for sediment classification and management. These pan-European EQS could be completed with EU targets for the prevention of sediment contamination that include pollution reduction plans specifically dedicated to sediments. Then sea-basin cooperation and national legislation should provide the possibility of defining more stringent limits for EQS and including additional specific substances associated with more detailed management guidelines. At the national level, EQS could be transformed into intervention thresholds and coupled with the application of site-specific risk analysis processes to define the details and objectives of intervention projects. The site-specific intervention definition and risk analysis processes would enable – as it is done already in Sweden, Netherlands and Flanders – to integrate the final use of the areas and the socio-economic aspects in the definition of the remediation plan. This legislative process could facilitate and promote the implementation of sediment decontamination and management plans using the BATNEEC approach (Best Available Techniques at Not Exceeding Excessive Cost). In fact, the endeavour of remediating all contaminated sediments across the EU would not make economic rationale and would have limited social impacts, especially if efforts are not put in place to eliminate pollutant sources. However, remediating sediments where it is urgently needed and technically possible must be a priority for all EU countries.

The plan is to prepare a Policy Position Paper during the coming months with the objective to present and discuss our proposal at the next SedNet conference in September. In fact, we submitted an abstract that was selected for a 20-minute presentation, the abstract is the base for the Policy Position Paper that is being prepared. After the SedNet conference we will collect additional feedback from key stakeholders in the sediment management sector to streamline our proposition. The next milestone for this process will be the divulgation event organized with Invitalia in Rome in Q1 2024, and with a direct involvement in the organization of the Italian Environment Ministry. On that occasion we will present the final position paper to be presented to the EU institutions and develop a specific proposal to tackle immediately the issues in the Italian national legislation that are slowing down the decontamination process in Bagnoli.

7. Key Project-level Indicators

Project data were included into KPI webtool in July 2022 (Assess the project's progress towards achieving the Key Project-level Indicator (KPI) targets (Annex 7.1). First evaluation of stat value of indicator 2.3.7 were established and reported in Annex 7.2 (it should be noted that some indicators have been repeated more than once and are highlighted in red in the table).

Annex

KPI annex
Annex 6.1.6 _Action B3

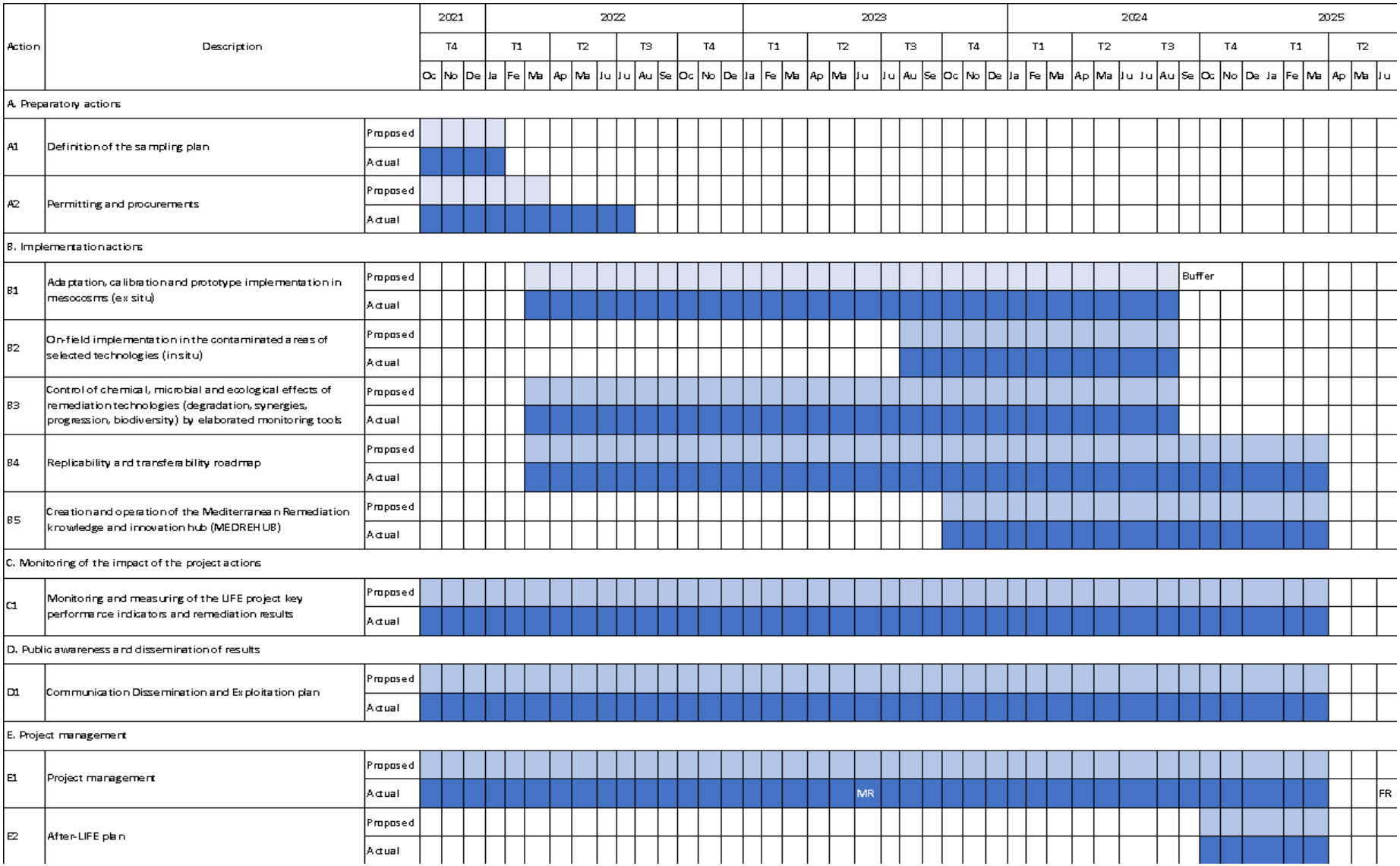

Figure 7 Gannt Chart of the LIFE SEDREMED project. MR: Mid-term report, FR: Final report.