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Life
**PHARMA
DETOX**

**Demonstration of an innovative method for the
detoxification of pharmaceutical wastewater
from pharmaceutical facilities**

**Deliverable C.1.4: 4th Update of LIFE project
performance indicators (KPIs)
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Disclaimer

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Abstract

This report presents the Life PHARMA-DETOX Key Performance Indicators as defined in the European Commission KPI platform. Due to some modifications in the process flow diagram of the plant and the capacity of the plant, as described in detail in the Deliverable A.1 Report on the modification of the original PFD, the KPIs related to the operation of the plant at Medochemie (such as the volume of treated wastewater, the mass output of waste, the energy efficiency of the plant, etc.) have been modified. The indicators related to the environmental and socio-economic impact of the project will also be updated through the dissemination activities of the project. These indicators relate to the people affected by the project's actions, both environmentally and socio-economically. The report covers the period from the start of the project (September 2021) to November 2024.

Keywords

▪ APIs ▪ Wastewater ▪ Pharmaceutical Industry ▪ Circular Economy ▪ Resource efficiency ▪ Circular economy ▪ Awareness Raising ▪ Networking ▪ Sustainability

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Abbreviations and Acronyms

APIs	Active Pharmaceuticals Ingredients
OPEX	Operating expenses
CAPEX	Capital expenditure
RO	Reverse Osmosis
PFD	Process Flow Diagram

Executive Summary

This report presents the Key Performance Indicators (KPIs) for the LIFE PHARMA-DETOX project (LIFE20 ENV/CY/000615), an initiative to detoxify pharmaceutical wastewater through an innovative and sustainable treatment system. The project focuses on minimizing the release of Active Pharmaceutical Ingredients (APIs) to water, promoting resource efficiency and supporting circular economic practices in the pharmaceutical industry.

As part of Action C.1 - Monitoring Protocol and Baseline Monitoring, this deliverable focuses to the methodology for monitoring the project's impact in six areas: environmental performance, resource efficiency, governance, public awareness, job creation and economic contribution. Regular updates of these indicators ensure continuous evaluation and optimization of project outcomes. The monitoring process focuses on the reduction in pharmaceutical pollutants, improvements in wastewater treatment efficiency, increased use of green practices and stakeholder engagement through awareness activities and capacity building initiatives.

The project promotes wastewater recycling activities, integrate renewable energy sources and facilitate collaboration with industry stakeholders and policy makers. Events such as conferences and training will raise awareness and share knowledge. The project will also lead to job creation and economic growth by replicating the prototype system at other European pharmaceutical sites. The report covers the period from the start of the project until November 2024. The KPIs related to the operation and capacity of the system at Medochemie (such as volume of treated wastewater, mass output of waste, energy efficiency of the system) have changed due to some updates in the process flow diagram of the system. The changes to the PFD are described in detail in the Deliverable A.1 Report on the modification of the original PFD.

1. Introduction

The LIFE PHARMA-DETOX aims to detoxify wastewater from the pharmaceutical industry. This will be achieved through the development and implementation of an innovative, economically viable, and cost-efficient system for the transformation of pharmaceutical compounds, present in wastewater, into non-toxic substances (detoxification process). The system will be able to treat the wastewater generated from production activities, ensuring that no APIs would end up in the wastewater sewage system without being processed and detoxified by the system-developed project.

The prototype system will be constructed in the context of the LIFE PHARMA-DETOX project LIFE20 ENV/CY/000615 and will be installed in Limassol, Cyprus in the pharmaceutical industry, named Medochemie.

Within the framework of the LIFE PHARMA-DETOX project, Action C.1 focuses on Monitoring Protocol and Baseline monitoring. The aim of this action is to establish KPIs and a Protocol that will be used for monitoring the outcomes of the project, as well as to acquire a clear and representative picture of the current situation (environmental and socio economic). Baseline monitoring will be done before the demonstration phase starts (Action C.2) and its results will be used as a reference. KPIs will be updated and include additional ones if deemed necessary for monitoring and assessing the impact of the project actions. The quantification of KPIs will be built on reliable data. For this to be achieved, several indicators will be set that are rational with the environmental problem targeted by LIFE PHARMA-DETOX project. Revision and updating of the Monitoring Protocol as well as of the list of indicators will be conducted periodically (every six months) so that the results can be evaluated and that adjustments can be made, if necessary. Modifications may take place by replacing an indicator with a corresponding one that may represent the information in a more concise and meaningful way. The list of indicators (and the corresponding values of indicators according to the phase of the project implementation) will be updated and reported regularly (every six months). These indicators are grouped under 6 categories. For all indicators the reasoning, their maturity, and their verification (source of verification: official statistics, survey, local authorities waste financial reports) will be identified and described during the implementation of actions C.2, C.3 and C.4.

A fuel cell is included, in the initial designs, to be used as an energy carrier for the remaining energy needs of the system when solar light is not available. However, given that the system will only operate during daylight hours, photovoltaics will sufficiently meet the system's energy demands. Consequently, the fuel cell will not be installed, as Medochemie policy requires continuous control of every operation, which would not be feasible. Solar energy will fully cover the system's energy requirements during daylight hours, eliminating the need for backup energy sources. Upon these modifications, the PFD has been changed respectively.

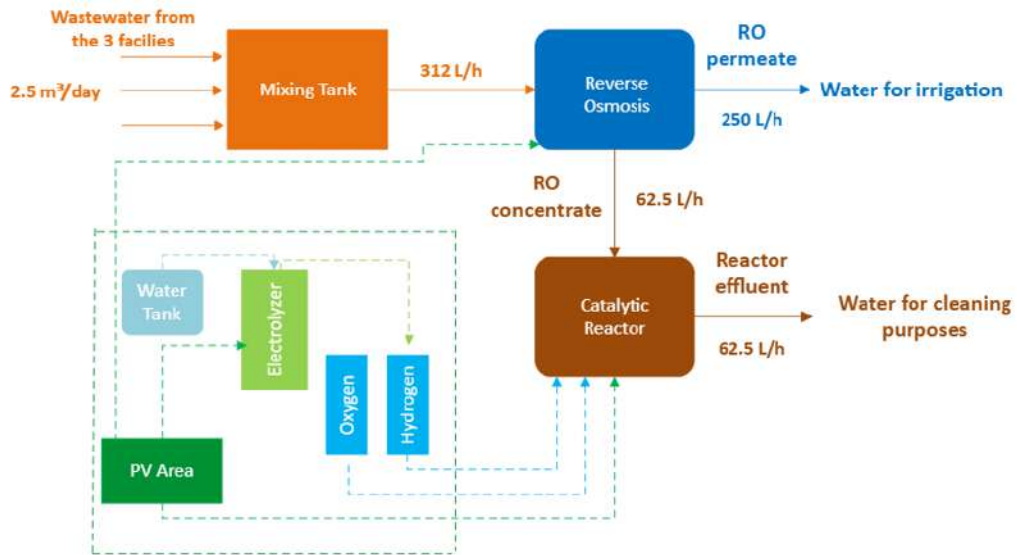


Figure 1-1 Updated Process Flow Diagram of the Life PHARMA-DETOX prototype system.



2. PHARMA-DETOX performance indicators

2.1 Project area – length

Table 1: Total spatial extent directly influenced by the project actions.

Indicators	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Area of environmental/climate implementation actions (e.g., development, testing, demonstration, application of best practices/innovations).	150 m ²	230 m ²	At the beginning of the project, the area of project work is equal to zero. The area of project work in each WWTP is equal to: 20 m ² (the space occupied by a container) +20 m ² the area around the container+70 m ² .for the Photovoltaic System=110 m ² . So, at the end of the project, the area of project work in Limassol and Duiven will be 110 m ² +40 m ² =150 m ² and beyond three years (Limassol, Duiven, Athens, Catania) will be 230 m ² (110 m ² +40 m ² *3).

2.2 Humans (to be influenced) by the project

Table 2: Number of individuals targeted by environmental actions and the related governance or information objectives of the project.

Indicators	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Persons who may have been influenced via dissemination or awareness raising project-actions (reaching)	Number of people: 7,875	Number of people: 11,975	More than 7,875 people will be influenced via the dissemination and awareness-raising actions by the end of the project. 100 people will attend the project's International Conference, 25 people will participate in each Stakeholder Consultation Event (25*3) =75 and 3,000 people will visit the project sites on the open days that will be organized for the public. Platforms such as Twitter and LinkedIn are expected to have more than 500 followers, while the project website will have 4,200 visits until the end of the project. Three (3) years later, the website and the social media (e.g., Twitter) will have 3,600 and 500 more visits, respectively. So, beyond 3 years, 11,975 people will be influenced by the dissemination of the project.

2.3 Water (including the marine environment)-Point source pollution

Table 3: The specific area affected by the concrete pressure or risk addressed by the project and the River Basin specific pollutants provoking pollution in this area. Reduction of the specific pollutants mass through the implementation of the project

Indicators	Absolute value at the beginning of the project	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
CAS_15687-27-1 - Ibuprofen	Total release APIs by Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical at the project begin: 16.53 kg/year	At the end of the project's implementation, it is estimated that 95% of APIs released from Medochemie and FAL Duiven will be detoxified, so the released APIs is: 10.33 kg/year	APIs released beyond three years of the project's implementation for Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical: 0.83 kg/year	<p>Penicillin antibiotics: Amoxycillin, Ampicillin, Cloxacillin. It is possible to find traces of these drugs or their degradation products in environmental water bodies. In the water bodies, these compounds may produce toxic effects on the aquatic organisms from different trophic levels and produce an ecological imbalance (bacterial resistance genes).</p> <p>Synthetic opioid: Tramadol. Inefficient removal in sewage treatment plants and increasing use over time.</p> <p>Psychiatric drugs: Prochlorperazine. Psychiatric pharmaceuticals have received particular attention because of their increasing use and their potential impacts on living beings due to their effects on phylogenetically highly conserved neuroendocrine systems.</p> <p>Antidepressant drugs: Diazepam. The biodegradability of Diazepam is often described as limited in the environment. Resistant to biological treatments in WWTPs. It is estimated that: -5.22 kg/year from the above pharmaceutical substances are produced by Medochemie. -1.31 kg/year from the above pharmaceutical substances are produced by FAL Duiven -5 kg/year from the above pharmaceutical substances are produced by Athens pharmaceutical company.</p>

				<p>-5 kg/year from the above pharmaceutical substances are produced by Catania pharmaceutical company.</p> <p>At the beginning, the total amount of the release APIs is 16.53 kg/year.</p> <p>At the end of the project it is estimated that 95% of APIs released from Medochemie and FAL Duiven will be detoxified so the released APIs will be $16.53 - (5.22+1.31) * 0.95 = 10.33$ kg/year.</p> <p>Beyond 3 years will be $16.53 - 16.53 * 0.95 = 0.83$ kg/year.</p> <p>The concentration of TN in wastewater is equal to 46 mg/l. The wastewater from the cleaning processes for Medochemie is 10 m³/d So the initial mass of TN in the production wastewater is 46 mg/l or 46 g/m³, $46 \text{ g/m}^3 * 10 \text{ m}^3/\text{d} * 365 \text{ d/y} = 167,900 \text{ g/y} = 167.9 \text{ kg/y}$.</p> <p>Duiven wastewater from the cleaning processes 2.5 m³/d, the initial mass of TN: $46 \text{ g/m}^3 * 2.5 \text{ m}^3/\text{d} * 365 \text{ d/y} = 41,975 \text{ g/y} = 42.0 \text{ kg/y}$</p> <p>Athens and Catania wastewater from the cleaning processes 9.6 m³/d, the initial mass of TN: $46 \text{ g/m}^3 * 9.6 \text{ m}^3/\text{d} * 365 \text{ d/y} = 161,184 \text{ g/y} = 161.2 \text{ kg/y}$</p> <p>At the end of the project: TN 90% removal.</p> <p>At the beginning: 4 pharmaceutical industries, $167.9 \text{ kg/y} + 42.0 \text{ kg/y} + 161.2 \text{ kg/y} * 2 = 532.3 \text{ kg/y}$</p> <p>At the end there are 2 pharmaceutical industries that have removed 90% of the pollutant $(0.1 * 167.9 + 0.1 * 42.0 + 161.2 * 2) = 343.4 \text{ kg/y}$</p> <p>Beyond three years, 4 industries will remove the pollutant up to 90%, $(167.9 + 42.0 + 161.2 * 2) * 0.1 = 53.23 \text{ kg/y}$.</p>
<p>EEA_31615-01-7 - Total nitrogen</p>	<p>Total Nitrogen release by Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical at the project begin: 532.30 kg/year</p>	<p>At the end of the project's implementation Medochemie, and FAL Duiven will remove 90% of the Total Nitrogen 343.40 kg/year</p>	<p>Beyond the three years of the project's implementation, Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical will remove the Total Nitrogen up to 90%, 53.23 kg/year</p>	
<p>EEA_3133-01-5 - BOD₅</p>	<p>BOD₅ released by Medochemie, FAL Duiven, Athens pharmaceutical, and</p>	<p>At the end of the project's implementation Medochemie,</p>	<p>Beyond the three years of the project's implementation, Medochemie, FAL Duiven, Athens</p>	<p>The concentration of BOD₅ in wastewater is equal to 270 mg/l. The wastewater from the cleaning processes for Medochemie is 10 m³/d. So, the initial mass of BOD₅ in the production</p>



<p>Catania pharmaceutical at the project begin: 3,124.00 kg/year</p>	<p>and FAL Duiven will remove 90% of the BOD₅. 2,015.40 kg/year</p>	<p>pharmaceutical, and Catania pharmaceutical will remove the BOD₅ up to 90%, 312.40 kg/year</p>
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wastewater is 270 mg/l or 270 g/m³, 270 g/m³ * 10 m³/d * 365 d/y = 985,500 g/y = 985.5 kg/y.
 Duiven wastewater from the cleaning processes 2.5 m³/d, the initial mass of BOD₅:
 270 g/m³ * 2.5 m³/d * 365 d/y = 246,375 g/y = 246.4 kg/y
 Athens and Catania wastewater from the cleaning processes 9.6 m³/d, the initial mass of BOD₅:
 270 g/m³ * 9.6 m³/d * 365 d/y = 946,080 g/y = 946.1 kg/y
 Removal of BOD₅ through the pilot system will be close to 90%.
 At the beginning: 4 pharmaceutical industries,
 985.5 kg/y + 246.4 kg/y + 946.1 kg/y * 2 = 3,124 kg/y
 At the end there are 2 pharmaceutical industries that have removed 90% of the pollutant
 (0.1 * 985.5 + 0.1 * 246.4 + 946.1 * 2) = 2,015.4 kg/y
 Beyond three years, 4 industries will remove the pollutant up to 90%,
 (985.5 + 246.4 + 946.1 * 2) * 0.1 = 312.4 kg/y

<p>CAS_7723-14-0 - Total phosphorus</p>	<p>Total phosphorus released by Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical at the project begin: 1,075.80 kg/year</p>	<p>At the end of the project's implementation Medochemie, and FAL Duiven will remove 90% of the Total phosphorus. 694.00 kg/year</p>	<p>Beyond the three years of the project's implementation, Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical will remove the Total phosphorus up to 90%, 107.60 kg/year</p>
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The concentration of TP in wastewater is equal to 92.98 mg/l. The wastewater from the cleaning processes for Medochemie is 10 m³/d. So, the initial mass of TP in the production wastewater is
 92.98 mg/l or 92.98 g/m³, 92.98 g/m³ * 10 m³/d * 365 d/y = 339,377 g/h = 339.4 kg/y
 Duiven wastewater from the cleaning processes 2.5 m³/d, initial mass of TP:
 92.98 g/m³ * 2.5 m³/d * 365 d/y = 84,844 g/y = 84.8 kg/y
 Athens and Catania wastewater from the cleaning processes 9.6 m³/d, initial mass of TP:
 92.98 g/m³ * 9.6 m³/d * 365 d/y = 325,801 g/y = 325.8 kg/y
 Removal of TP through the pilot system will be close to 90%.

<p>CAS_15307-79-6 - Diclofenac sodium</p>	<p>Diclofenac sodium released by Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical at the project begin: 1,365.40 g/year</p>	<p>At the end of the project's implementation Medochemie, and FAL Duiven will remove 90% of the Diclofenac sodium 880.80 g/year</p>	<p>Beyond the three years of the project's implementation, Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical will remove the Diclofenac sodium up to 90%, 136.50 g/year</p>	<p>At the beginning: 4 pharmaceutical industries, 339.4 kg/y + 84.8 kg/y + 325.8 kg/y *2= 1,075.8 kg/y At the end there are 2 pharmaceutical industries which have removed 90% of the pollutant (0.1*339.4 +0.1*84.8 +325.8*2) = 694.0 kg/y Beyond three years 4 industries will remove the pollutants up to 90%, (339.4 +84.8 +325.8 *2) *0.1=107.6 kg/y. The concentration of diclofenac sodium in wastewater is 0.118 mg/l. The wastewater from the cleaning processes for Medochemie is 10 m³/d. So, the initial mass of diclofenac sodium in the production wastewater is 0.118 mg/l or 0.118 g/m³, 0.118 g/m³ * 10 m³/d* 365 d/y= 430.7 g/y. Duiven wastewater from the cleaning processes 2.5 m³/d, the initial mass of diclofenac sodium: 0.118 g/m³ * 2.5 m³/d *365 d/y =107.7 g/y Athens and Catania wastewater from the cleaning processes 9.6 m³/d, initial mass of TN: 0.118 g/m³ * 9.6 m³/d *365 d/y =413.5 g/y Removal of diclofenac sodium through the pilot system will be close to 90%. At the beginning: 4 pharmaceutical industries, 430.7 g/y + 107.7 g/y + 413.5 g/y *2= 1,365.4 g/y. At the end there are 2 pharmaceutical industries which have removed 90% of the pollutant (0.1*430.7 +0.1*107.7 +413.5*2) = 880.8 g/y Beyond three years 4 industries will remove the pollutants up to 90%, (430.7 +107.7 +413.5 *2) *0.1=136.5 g/y.</p>
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2.4 Resource efficiency – Energy

Table 4: Renewable energy production- solar energy

Indicators	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Solar Energy	4,652 kWh/year	11,562 kWh/year	<p>At the end of the project: It is estimated that for the collection and treatment of 1 m³ of wastewater in a WWTP 1 KWh is needed. The PHARMA-DETOX system in Limassol will have the capacity to treat approx. 10 m³ of wastewater per day. Thus, 3650 m³/year will be treated, and 3,650 KWh/year will be saved as the system will use energy 100% from RES. At the replication in the Netherlands, the proposed system will treat all the quantity of wastewater produced, about 2,5 m³/day. Thus, 912 m³/year will be treated, and 912 KWh/year will be saved as the system will use energy 100% from RES.</p> <p>In addition, 3,650 KWh/year+912 KWh/year=4,562 KWh/year will be saved by the operation of the two systems.</p> <p>Beyond 3 years: For the 2 new systems foreseen, it is estimated that will be saved 3,500 KWh/year for each system (we assume 9.5 m³ of wastewater /day). 4,562 KWh/year + 3,500 KWh/year + 3,500 KWh/year = 11,562 KWh / year.</p>

2.5 Resource efficiency – Circular economy

Table 5: Mass of output of waste, number of entities where green circular economy practices are implemented, mass of input of recycled or reused waste, and number of pharmaceuticals products produced.

Indicators	Absolute value at the beginning of the project	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Mass of output of waste per unit produced (or per mass of unit produced)	0.65 tn/tn unit produced	0.38 tn/tn unit produced	0 tn/tn unit produced	Medochemie Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,182 tn/year Waste: 10 m ³ /day=3,650 tn/year

				FAL Duiven Production of final pharmaceutical products (ampoules, caps,tabs,vials): 1,450 tn/year Waste: 2.5 m ³ /day=912.5 tn/year Athens Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Catania Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Recycled waste: start: 0. end: 4,562 tn/year 3 years after 10,840 tn/year Mass of output of waste/unit produced: at the beginning: 10,840/16,632=0.65 at the end: (10,840-4,562)/16,632=0.38 3 years after: (10,840-10,840)/ 16,632=0
Number of entities where green circular economy practices are implemented	0 n. of entities	2 n. of entities	4 n. of entities	Medochemie Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,182 tn/year Waste: 10 m ³ /day=3,650 tn/year FAL Duiven Production of final pharmaceutical products (ampoules, caps,tabs,vials): 1,450 tn/year Waste: 2.5 m ³ /day=912.5 tn/year Athens Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Catania Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Recycled waste: start: 0 entities end: 2 entities 3 years after 4 entities
Mass of input of actually recycled or reused waste per unit produced (or per mass of unit produced)	0 tn/tn unit produced	0.27 tn/tn unit produced	0.65 tn/tn unit produced	Medochemie Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,182 tn/year Waste: 10 m ³ /day=3,650 tn/year FAL Duiven



				Production of final pharmaceutical products (ampoules, caps,tabs,vials): 1,450 tn/year Waste: 2.5 m ³ /day=912.5 tn/year Athens Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Catania Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Recycled waste: start: 0. end: 4,562 tn/year 3 years after 10,840 tn/year Mass of input of recycled or reused waste/unit produced: at the beginning: 0 at the end: 4,562 /16,632=0.27 3 years after: 10,840 /16,632=0.65
				Medochemie Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,182 tn/year Waste: 10 m ³ /day=3,650 tn/year FAL Duiven Production of final pharmaceutical products (ampoules, caps,tabs,vials): 1,450 tn/year Waste: 2.5 m ³ /day=912.5 tn/year Athens Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Catania Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Recycled waste: start: 0. end: 4,562 tn/year 3 years after 10,840 tn/year Number of units produced/year: at the beginning: 16,632 units at the end: 16,632 units 3 years after: 16,632 unitsat the beginning: 16,632 units at the end: 16,632 units
Number of units produced/year	16,632 units	16,632 units	16,632 units	

3 years after: 16,632 units

2.6 Environment and health (including chemicals and noise)-Chemicals released.

Table 6: Mass of produced pharmaceuticals substances registered in ECHA list released.

Indicators	Absolute value at the beginning of the project	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Substance in ECHA list of registered substances	16.53 kg/year released	10.33 kg/year released	0.83 kg/year released	200-709-7/Ampicillin 248-003-8/Amoxicillin 615-253-8/Meloxicam 200-514-7/Cloxacillin 248-319-6/Tramadol 200-379-4/Prochlorperazine 212-687-6/Lorazepam 237-148-2/Nefopam 200-003-9/Dexamethasone It is estimated that: 5.22 kg/year from the above pharmaceutical substances are produced by Medochemie. 1.31 kg/year from the above pharmaceutical substances are produced by FAL Duiven 5 kg/year from the above pharmaceutical substances are produced by Athens pharmaceutical company 5 kg/year from the above pharmaceutical substances are produced by Catania pharmaceutical company In the beginning, the total amount of the release APIs is 16.53 kg/year

At the end of the project, it is estimated that 95% of APIs released from Medochemie and FAL Duiven will be detoxified, so the released APIs will be $16.53 - (5.22 + 1.31) * 0.95 = 10.33$ kg/year.
 Beyond 3 years will be $16.53 - 16.53 * 0.95 = 0.83$ kg/year

2.7 Governance

Table 7: Number of stakeholders involved in the project. Stakeholders are groups, public bodies, organizations, individuals, businesses, manufactures, pharmaceuticals companies, authorities, NGOs etc. that can be affected by the project activities and/or influence their implementation

Indicators	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Public body/bodies: Higher education, General public administration activities	100 number of individuals	100 number of individuals	This category includes national authorities: Cyprus Department of Environment of the Ministry of Agriculture (1), Cyprus Water Development Department of the Ministry of Agriculture (1), Sewerage Boards of Nicosia, Limassol, Paphos, Paralimni, Athienou and Larnaka (1), General Inspectorate for Environmental Protection (1), General Directorate for Environmental Protection (1) and Cyprus Ministry of Health (1). General Public: (not easy to be assessed). Scientific Community and Specialists in the field: people who will attend the International Conference (100 attendants) and people who will read the project's scientific publications (not easy to assess).
Private profit: -Water supply; sewage; waste management and remediation activities -Electricity, gas, steam, and air conditioning supply -Financial and insurance activities -Professional, scientific, and technical activities -Waste treatment and disposal	110 number of individuals	110 number of individuals	Stakeholders from pharmaceutical industry (individuals): There are over 400 manufacturing and research and development sites across Europe, but 50-60 % of the wastewater that they produced was released to the environment. Already, over 100 pharmaceutical companies have formed an alliance to combat antibiotic resistance, and one of their goals is to minimize the emissions of antibiotics in the effluents of the pharmaceutical manufacturing plants. Stakeholders from the process industries: With the view of the transferability of the project results, the project consortium has identified other industries that generate wastewater containing toxic compounds that would need to be detoxified before being released to the environment. The EU will most probably apply the same guidelines that would be applied to pharmaceutical compounds in wastewater to other chemical compounds that could cause environmental damage. So, the end-users of the technology proposed in this proposal can be



<p>-Manufacture of basic pharmaceutical products and pharmaceutical preparations</p>			<p>broadened to include chemical industries producing paints, cosmetics, chemicals for industry and laboratory use, petrochemicals, polymers, plastics, and specialty chemicals.</p> <p>Investor communities: This category refers to private investors (10). With the view to immediate follow-up funding after the project completion, the project partners will attend investor-related events and will organize bilateral meetings with institutional investors/venture capital funds.</p> <p>Wastewater Treatment plants: The technology proposed in this proposal can be applied to already existing and operating and new wastewater treatment plants as an additional tertiary treatment. Technology can be applied to urban wastewater treatment plants as well as smaller wastewater treatment plants for smaller communities, hospitals, and nursing homes.</p>
<p>Involvement of NGOs and other stakeholders in project activities.</p>	<p>30 number of individuals</p>	<p>60 number of individuals</p>	<p>The Stakeholders involved in the project's activities comprise of National and Regional Authorities, policy makers, the scientific community and specialists in the field, the investor community, the pharmaceutical industry, the water market, other process industries, and the public. More than 30 of the abovementioned stakeholders will be involved in the project's implementation. Beyond 3 years this number is expected to rise, as the project's prototype system will be implemented in at least three other demo sites, one in the Netherlands, one in Greece and one in Italy.</p>

2.8 Information and awareness activities: website and other tools for reaching/raising awareness of the general public

Table 8: Use of website and other tools, such as printed media, videos, events/exhibitions, posters, information boards etc. for reaching and raising awareness to the public

Indicators	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Website	Number of unique visits: 4,200	Number of unique visits: 7,800	It is estimated that more than 100 visits per month will take place on the project website, which was fully operational at M6. The project's time will be 48 months, so the website will be operational for the 48-6=42 months of the project and at the end of it, the number of visits will be 42*100=4,200. Three (3) years after the end of the project, the number of website visits is estimated to be 4,200 +(3*12) *100=4,200 + 3,600 = 7,800. The website will operate during the implementation of the LIFE project and for at least five more years after the end of the project.
Displayed information (poster,	Number of outcomes: 1	Number of outcomes: 2	1 noticeboard has been created for the partners' premises as is mentioned in the Grant Agreement (during the first year of the project). One more noticeboard will be designed after the end of the project to be placed in the Athens and Catania pharmaceutical industries.



information boards)			
Events/Exhibitions	Number of outcomes: 18	Number of outcomes: 20	<p>At least eighteen (18) events are foreseen by the Grant Agreement. One (1) International Conference will be organised in the last month of the project. Three (3) stakeholder consultation events will be organized. Five (5) organized site visits will be scheduled, so that relevant stakeholders can see the prototype system in real-life. At least three (3) open days will be organized for the public on the project's sites. Two (2) Information Kiosks will be organized in two different trade events, where the partners will provide information about the project using suitable material (leaflets and business plan). Then, they must participate in at least two (2) editions of the world-class Global Water Summit events, in one (1) edition of the Water Innovation Europe and in one (1) edition of the Water Market Europe organized by the European Technology Platform on Water (WssTP). Beyond 3 years, there are more 2 open days in Athens and Catania. Information will also be offered to websites that publish on wastewater treatment, circular economy, and the pharmaceutical industry (1). At least four (4) press releases are expected to target professionals, policy makers and the public. Every six months, a newsletter will be prepared in all languages of the project (8). Three videos will be prepared regarding the design, construction, and installation of the prototype system (1), the business results of the project (1) and the environmental challenges the project focuses on (1). After the completion of the design (Action B.1), an international patent will be filed for Patent Cooperation Treaty. This will grant time to the inventors to select which countries are of high importance for our technology. After this screening process, national patents will be filed. A patent will be applied within the project implementation. The patent that will be submitted for the Pharma Detox prototype system is one.</p>
Other media (video/broadcast/leaflets)	Number of outcomes: 16	Number of outcomes: 16	
Patents	Number of outcomes: 1	Number of outcomes: 1	

2.9 Capacity building: Networking & Professional training or education

Table 9: Number of individuals included in or participate in the project's networking and in different training or education activities taking place within the project.

Indicators	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Networking-Professionals - experts in the field	Number of individuals: 400	Number of individuals: 400	Regarding the professionals that will attend the project's international conference (100 attendants), the three stakeholder consultant events (25 participants per event: 25*3=75), and the networking of the project (42 networking projects will be at least 1 person from each project), the relevant stakeholders that will visit the installation site (will



be organized at least 4 site visits), those that will be informed about the project by our partners who will participate in relevant trade events (2 trade events), around 400 people are estimated to participate in the project's network.

Professional Training or Education-Members of interest groups / lobby organisations	Number of individuals: 200	Number of individuals: 200	At least four (4) site visits/training sessions will be scheduled targeting pharmaceutical industry operators, as well as policymakers (1 visit). Efforts will be made so that at least two (2) schools/universities will participate in one site visit. Taking the above into consideration, approximately 200 people will be trained during the Life Project.
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2.10 Jobs

Table 10: Indication of the jobs created by the project via the Full Time Equivalent

Indicators	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Jobs	FTE: 9.25	0.54	The indicator value is based on the FTE calculation formula. As is mentioned in the Grant Agreement, by the end of the project, additional staff will be needed for Actions. Especially the cumulative number of person-days is 2,036 for additional staff. The annual Full-Time Equivalent is equal to 220 full working days per year. $FTE = 2,036 / 220 = 9.25$. Beyond three years, two systems will be implemented in Athens and Catania. It is estimated that the construction of each system will require 60 working days in total. 15 days for designing and construction supervision from an engineer and 45 days for construction of the system from technicians. $60 / 220 = 0.27$ FTE. The total FTE for the two systems is $0.27 \times 2 = 0.54$. So beyond three years, the total FTE will be 0.54.

2.11 Contribution to economic growth

Table 11: Operating costs during the project's activities, capital expenses and operating expenses in case of continuation, replication, transfer of the project after its implementation, potential of future funding, replication-transfer of the project in new sectors and new geographical areas

Indicators	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Running cost/operating costs during the project and expected in case of continuation/replication/transfer after the project period	Total cost of the project: 3,340,922 €	Total cost of the project: 4,771,872 €	The total cost of the project is 3,340,922 €. This cost has concluded with the construction of the pilot system in Limassol and Duiven. Beyond three years, the construction budget of the pilot systems in Athens and Catania is estimated to be 1,430,950 €, based on the budget which is required for the Action B2 Construction of the prototype LIFE PHARMA DETOX (715,475€ x 2). $3,340,922 + 1,430,950 = 4,771,872$ €. During tests which will be done through Sub-Action B.4.3, extra data will be provided for the estimation of OPEX of these systems.
Capital expenditure expected in case of continuation/replication/transfer after the project period	The value will be provided later	The value will be provided later	The Capital Expenditure, which is expected in case of continuation/replication/transfer after the project period, will be calculated within sub-action B.5.1: Business Plan and Investment Memorandum, which will be implemented from M16 to M42. So, the CAPEX will be provided at the final report stage.
Operating expenses expected in case of continuation/replication/transfer after the project period.	The value will be provided later	The value will be provided later	The operating expenses expected in the case of continuation/replication/transfer after the project period will be calculated within action B.5.1: Business Plan and Investment Memorandum, based on the actual costs incurred in the project for the construction and operation of the prototype. The OPEX value will be provided at the final report stage.
Future funding- Grants, subsidies	Grants, subsidies	Grants, subsidies	Within Sub-Action B.5.1: Business Plan and Investment Memorandum, an analysis will be conducted for the identification of the ways to achieve maximum exploitation of the project results, market replication and return on investment. The value will be provided at the final report stage.
Continuation/replication/transfer after the project period: Entry		Number of sectors: 1	The pilot system will be transferred to the organic chemical industry.



into new sectors-Manufacture of chemicals and chemical products

Continuation/replication/transfer after the project period: Entry into new geographical areas

Number of geographical areas: 3

Within the Sub-action B.4.2: Demonstration of the prototype in another pharmaceutical production industry-2nd demonstration phase of the project, the system will be demonstrated to another pharmaceutical industry in the Netherlands. Replicability studies will also be conducted for two other pharmaceutical companies in Greece and Italy.

3. PHARMA-DETOX performance indicators from the beginning of the project until 31/05/2023

3.1 Humans (to be influenced) by the project

Table 12: Number of individuals targeted by environmental actions and the related governance or information objectives of the project.

Indicators	Impact during 09/2021-05/2023	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Persons who may have been influenced via dissemination or awareness raising project-actions (reaching)	410	Number of people: 7,875	Number of people: 11,975	According to Google Analytics, there were 161 unique visits during this period. There are also, 149 followers on Twitter, and LinkedIn. 100 people were influenced by the dissemination of the project at the 1st Verdetech in which we participated, presenting the project, informing them and providing leaflets. In total, 410 individuals have been reached or influenced through the project's dissemination and awareness-raising activities (161 unique visits + 149 social media followers+ 100 people in 1 st Verdetech).

3.2 Information and awareness activities: website and other tools for reaching/raising awareness of the general public

Table 13: Use of website and other tools, such as printed media, videos, events/exhibitions, posters, information boards etc. for reaching and raising awareness to the public

Indicators	Impact during 09/2021-05/2023	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Website	161	Number of unique visits: 4,200	Number of unique visits: 7,800	It was reported by Google Analytics that for this period 161 unique visits were-conducted.

3.3 Governance

Table 14: Number of stakeholders involved in the project. Stakeholders are groups, public bodies, organizations, individuals, businesses, manufactures, pharmaceuticals companies, authorities, NGOs etc. that can be affected by the project activities and/or influence their implementation

Indicators	Impact during 09/2021-05/2023	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Public body/bodies: Higher education, General public administration activities	40	100 number of individuals	100 number of individuals	40 specialists affected by the project activities and influence by their implementation though the 1st Verdetech.

3.4 Capacity building: Networking & Professional training or education

Table 15: Number of individuals included in or participate in the project's networking and in different training or education activities taking place within the project.

Indicators	Impact during 09/2021-05/2023	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Networking-Professionals - experts in the field	100	Number of individuals: 400	Number of individuals: 400	100 individuals participated in the project's networking activities during this period. These individuals were from other EU-funded programs with relevant topics of interest and professionals experts in the field.

4. PHARMA-DETOX performance indicators from the beginning of the project until 30/11/2023

4.1 Humans (to be influenced) by the project

Table 16: Number of individuals targeted by environmental actions and the related governance or information objectives of the project.

Indicators	Impact during 09/2021-11/2023	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Persons who may have been influenced via dissemination or awareness raising project-actions (reaching)	810	Number of people: 7,875	Number of people: 11,975	<p>According to Google Analytics, there were 496 unique visits during this period. There are also 264 followers on Twitter and LinkedIn. 50 people were influenced by the dissemination of the project at the 10th International Conference on Sustainable Solid Waste Management Chania, Greece, 21 - 24 JUNE 2023 in which we participated, presenting the project, informing them and providing leaflets</p> <p>In total, 810 individuals have been reached or influenced through the project's dissemination and awareness-raising activities (496 unique visits + 264 social media followers+50 people in 10th International Conference on Sustainable Solid Waste Management Chania).</p>

4.2 Governance

Table 17: Number of stakeholders involved in the project. Stakeholders are groups, public bodies, organizations, individuals, businesses, manufactures, pharmaceuticals companies, authorities, NGOs etc. that can be affected by the project activities and/or influence their implementation

Indicators	Impact during 09/2021-11/2023	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Public body/bodies: Higher education, General public administration activities	45	100 number of individuals	100 number of individuals	At the 1 st stakeholder meeting participated 5 people from Sewerage Boards of Limassol and Cyprus Department of Environment of the Ministry of Agriculture. Total 40 from previous update+5=45
Private profit: -Water supply; sewage; waste management and remediation activities -Electricity, gas, steam, and air conditioning supply -Financial and insurance activities -Professional, scientific, and technical activities -Waste treatment and disposal -Manufacture of basic pharmaceutical products and pharmaceutical preparations	15	110 number of individuals	110 number of individuals	At the 1 st stakeholder meeting participated 15 people from pharmaceutical and process industries.
Involvement of NGOs and other stakeholders in project activities.	34 stakeholders	30 number of individuals	60 number of individuals	The 1 st Stakeholder Consultation Event was held with 34 stakeholders attending.

4.3 Information and awareness activities: website and other tools for reaching/raising awareness of the general public

Table 18: Use of website and other tools, such as printed media, videos, events/exhibitions, posters, information boards etc. for reaching and raising awareness to the public

Indicators	Impact during 09/2021-11/2023	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Website	496	Number of unique visits: 4,200	Number of unique visits: 7,800	It was reported by Google Analytics that for this period 496 unique visits were-conducted.
Events/Exhibitions	1	Number of outcomes: 18	Number of outcomes: 20	During this period the 1 st stakeholder event held.
Other media (video/broadcast/leaflets)	1	Number of outcomes: 16	Number of outcomes: 16	During this period published the first (1) project newsletter.

4.4 Capacity building: Networking & Professional training or education

Table 19: Number of individuals included in or participate in the project's networking and in different training or education activities taking place within the project.

Indicators	Impact during 09/2021-11/2023	Estimated Impact (absolute values)	Estimated impact (absolute values)	Brief explanations of assumptions used for the calculations of values indicators
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		at the end of the project	beyond three years	
Networking- Professionals - experts in the field	164	Number of individuals: 400	Number of individuals: 400	34 people attended the 1st stakeholder consultation meeting and 30 experts in field participate active as stakeholders from 10 th International Conference on Sustainable Solid Waste Management Chania. Total (100 people already involved in the project's networking) + 34 stakeholders+30 experts in field = 164 people.

5. PHARMA-DETOX performance indicators from the beginning of the project until 31/05/2023

5.1 Humans (to be influenced) by the project

Table 20: Number of individuals targeted by environmental actions and the related governance or information objectives of the project.

Indicators	Impact during 09/2021-05/2024	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Persons who may have been influenced via dissemination or awareness raising project-actions (reaching)	1288	Number of people: 7,875	Number of people: 11,975	According to Google Analytics, there were 801 unique visits during this period. There are also 387 followers on Twitter and LinkedIn. 100 people were influenced by the dissemination of the project at the 2 nd Verdetch in which we participated, presenting the project, informing them and providing leaflets. In total, 1288 individuals have been reached or influenced through the project's dissemination and awareness-raising activities (801 unique visits + 387 social media followers+ 100 people in 2 nd Verdetch).

5.2 Governance

Table 21: Number of stakeholders involved in the project. Stakeholders are groups, public bodies, organizations, individuals, businesses, manufactures, pharmaceuticals companies, authorities, NGOs etc. that can be affected by the project activities and/or influence their implementation

Indicators	Impact during 09/2021-05/2024	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Public body/bodies: Higher education, General public administration activities	45	100 number of individuals	100 number of individuals	40 specialists affected by the project activities and influence by their implementation though the 2 nd Verdetech. Total 45 from previous update+40=85
Private profit: -Water supply; sewage; waste managment and remediation activities -Electricity, gas, steam, and air conditioning supply -Financial and insurance activities -Professional, scientific, and technical activities -Waste treatment and disposal -Manufacture of basic pharmaceutical products and pharmaceutical preparations	55	110 number of individuals	110 number of individuals	40 people from wastewater disposal, water supply industries and sewage waste management, affected by the project activities and influence by their implementation though the 2 nd Verdetech. Total 15 from previous update+40=55

5.3 Information and awareness activities: website and other tools for reaching/raising awareness of the general public

Table 22: Use of website and other tools, such as printed media, videos, events/exhibitions, posters, information boards etc. for reaching and raising awareness to the public

Indicators	Impact during 09/2021-05/2024	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Website	801	Number of unique visits: 4,200	Number of unique visits: 7,800	It was reported by Google Analytics that for this period 801 unique visits were-conducted.
Other media (video/broadcast/leaflets)	2	Number of outcomes: 16	Number of outcomes: 16	During this period the second project newsletter was published.
Displayed information (poster, information boards)	1	Number of outcomes: 1	Number of outcomes: 2	The project noticeboards were placed at the partner's premises, and photographs were taken of them.

5.4 Capacity building: Networking & Professional training or education

Table 23: Number of individuals included in or participate in the project's networking and in different training or education activities taking place within the project.

Indicators	Impact during	Estimated Impact	Estimated impact	Brief explanations of assumptions used for the calculations of values indicators
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	09/2021-05/2024	(absolute values) at the end of the project	(absolute values) beyond three years	
Networking-Professionals - experts in the field	204	Number of individuals: 400	Number of individuals: 400	40 experts in the field participate active as stakeholders in 2 nd Verdetech. Total (164 people already involved in the project's networking) + 40 experts in the field = 204 people.

6. PHARMA-DETOX performance indicators from the beginning of the project until 30/11/2023

6.1 Humans (to be influenced) by the project

Table 24: Number of individuals targeted by environmental actions and the related governance or information objectives of the project.

Indicators	Impact during 09/2021-11/2024	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Persons who may have been influenced via dissemination or awareness raising project-actions (reaching)	7,997	Number of people: 7,875	Number of people: 11,975	<p>According to Google Analytics, there were 7,328 unique visits during this period. There are also 519 followers on Twitter and LinkedIn. 100 people were influenced by the dissemination of the project at the 3rd Verdetech and 50 people in the 11th International Conference on Sustainable Solid Waste Management Rhodes, Greece, 19 - 22 JUNE 2024 in which we participated, presenting the project, informing them and providing leaflets.</p> <p>In total, 7,997 individuals have been reached or influenced through the project's dissemination and awareness-raising activities (7,328 unique visits + 519 social media followers+100 people in 3rd Verdetech+50 people in 11th International Conference on Sustainable Solid Waste Management Rhodes).</p>

6.2 Water (including the marine environment)-Point source pollution

Table 25: The specific area affected by the concrete pressure or risk addressed by the project and the River Basin specific pollutants provoking pollution in this area. Reduction of the specific pollutants mass through the implementation of the project

Indicators	Absolute updated value at the beginning of the project	Updated Estimated Impact (absolute values) at the end of the project	Updated Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
CAS_15687-27-1 - Ibuprofen	Total release APIs by Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical at the project begin: 16.53 kg/year	At the end of the project's implementation, it is estimated that 95% of APIs released from Medochemie and FAL Duiven will be detoxified, so the released APIs is: 10.33 kg/year	APIs released beyond three years of the project's implementation for Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical: 0.83 kg/year	<p>Penicillin antibiotics: Amoxycillin, Ampicillin, Cloxacillin. It is possible to find traces of these drugs or their degradation products in environmental water bodies. In the water bodies, these compounds may produce toxic effects on the aquatic organisms from different trophic levels and produce an ecological imbalance (bacterial resistance genes).</p> <p>Synthetic opioid: Tramadol. Inefficient removal in sewage treatment plants and increasing use over time.</p> <p>Psychiatric drugs: Prochlorperazine. Psychiatric pharmaceuticals have received particular attention because of their increasing use and their potential impacts on living beings due to their effects on phylogenetically highly conserved neuroendocrine systems.</p> <p>Antidepressant drugs: Diazepam. The biodegradability of Diazepam is often described as limited in the environment. Resistant to biological treatments in WWTPs.</p> <p>It is estimated that: -5.22 kg/year from the above pharmaceutical substances are produced by Medochemie. -1.31 kg/year from the above pharmaceutical substances are produced by FAL Duiven -5 kg/year from the above pharmaceutical substances are produced by Athens pharmaceutical company.</p>

				<p>-5 kg/year from the above pharmaceutical substances are produced by Catania pharmaceutical company.</p> <p>At the beginning, the total amount of the release APIs is 16.53 kg/year.</p> <p>At the end of the project it is estimated that 95% of APIs released from Medochemie and FAL Duiven will be detoxified so the released APIs will be $16.53 - (5.22+1.31) * 0.95 = 10.33$ kg/year.</p> <p>Beyond 3 years will be $16.53 - 16.53 * 0.95 = 0.83$ kg/year.</p> <p>The concentration of TN in wastewater is equal to 46 mg/l. The updated volume of wastewater from the cleaning processes for Medochemie is 2.5 m³/d So the initial mass of TN in the production wastewater is 46 mg/l or 46 g/m³, $46 \text{ g/m}^3 * 2.5 \text{ m}^3/\text{d} * 250 \text{ d/y} = 28,750 \text{ g/y} = 28.75 \text{ kg/y}$.</p> <p>Duiven wastewater from the cleaning processes 2.5 m³/d, the initial mass of TN: $46 \text{ g/m}^3 * 2.5 \text{ m}^3/\text{d} * 365 \text{ d/y} = 41,975 \text{ g/y} = 42.0 \text{ kg/y}$ Athens and Catania wastewater from the cleaning processes 9.6 m³/d, the initial mass of TN: $46 \text{ g/m}^3 * 9.6 \text{ m}^3/\text{d} * 365 \text{ d/y} = 161,184 \text{ g/y} = 161.2 \text{ kg/y}$ At the end of the project: TN 90% removal. At the beginning: 4 pharmaceutical industries, $28.75 \text{ kg/y} + 42.0 \text{ kg/y} + 161.2 \text{ kg/y} * 2 = 393.15 \text{ kg/y}$ At the end there are 2 pharmaceutical industries that have removed 90% of the pollutant $(0.1 * 28.75 + 0.1 * 42.0 + 161.2 * 2) = 329.475 \text{ kg/y}$ Beyond three years, 4 industries will remove the pollutant up to 90%, $(167.9 + 42.0 + 161.2 * 2) * 0.1 = 39.315 \text{ kg/y}$.</p>
EEA_31615-01-7 - Total nitrogen	Total Nitrogen release by Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical at the project begin: 393.15 kg/year	At the end of the project's implementation Medochemie, and FAL Duiven will remove 90% of the Total Nitrogen 329.475 kg/year	Beyond the three years of the project's implementation, Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical will remove the Total Nitrogen up to 90%, 39.315 kg/year	
EEA_3133-01-5 - BOD ₅	BOD ₅ released by Medochemie, FAL Duiven, Athens pharmaceutical, and	At the end of the project's implementation Medochemie,	Beyond the three years of the project's implementation, Medochemie, FAL Duiven, Athens	The concentration of BOD ₅ in wastewater is equal to 270 mg/l. The updated volume of wastewater from the cleaning processes for Medochemie is 2.5 m ³ /d. So, the initial mass of



Catania pharmaceutical at the project begin: 2,307.35 kg/year and FAL Duiven will remove 90% of the BOD₅. 1,933.715 kg/year pharmaceutical, and Catania pharmaceutical will remove the BOD₅ up to 90%, 230.735 kg/year

BOD₅ in the production wastewater is 270 mg/l or 270 g/m³, 270 g/m³ * 2.5 m³/d * 250 d/y= 168,750 g/y =168.75 kg/y. Duiven wastewater from the cleaning processes 2.5 m³/d, the initial mass of BOD₅: 270 g/m³ * 2.5 m³/d * 365 d/y =246,375 g/y = 246.4 kg/y Athens and Catania wastewater from the cleaning processes 9.6 m³/d, the initial mass of BOD₅: 270 g/m³ * 9.6 m³/d * 365 d/y = 946,080 g/y = 946.1 kg/y Removal of BOD₅ through the pilot system will be close to 90%. At the beginning: 4 pharmaceutical industries, 168.75 kg/y + 246.4 kg/y + 946.1 kg/y *2= 2,307.35 kg/y At the end there are 2 pharmaceutical industries that have removed 90% of the pollutant (0.1* 168.75+0.1*246.4+946.1*2) = 1,933.715 kg/y Beyond three years, 4 industries will remove the pollutant up to 90%, (168.75+ 246.4 + 946.1*2) *0.1 = 230.735 kg/y

CAS_7723-14-0 - Total phosphorus

Total phosphorus released by Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical at the project begin: 794.51 kg/year

At the end of the project's implementation Medochemie, and FAL Duiven will remove 90% of the Total phosphorus. 665.891 kg/year

Beyond the three years of the project's implementation, Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical will remove the Total phosphorus up to 90%, 79.451 kg/year

The concentration of TP in wastewater is equal to 92.98 mg/l. The updated volume of wastewater from the cleaning processes for Medochemie is 2.5 m³/d. So, the initial mass of TP in the production wastewater is 92.98 mg/l or 92.98 g/m³, 92.98 g/m³ * 2.5 m³/d * d/y=58,112.5 g/h= 58.11 kg/y Duiven wastewater from the cleaning processes 2.5 m³/d, initial mass of TP: 92.98 g/m³ * 2.5 m³/d * 365 d/y =84,844 g/y=84.8 kg/y Athens and Catania wastewater from the cleaning processes 9.6 m³/d, initial mass of TP: 92.98 g/m³ * 9.6 m³/d * 365 d/y =325,801 g/y= 325.8 kg/y Removal of TP through the pilot system will be close to 90%. At the beginning: 4 pharmaceutical industries, 58.11 kg/y + 84.8 kg/y + 325.8 kg/y *2= 794.51 kg/y

<p>CAS_15307-79-6 - Diclofenac sodium</p>	<p>Diclofenac sodium released by Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical at the project begin: 1,008.45 g/year</p>	<p>At the end of the project's implementation Medochemie, and FAL Duiven will remove 90% of the Diclofenac sodium 845.15 g/year</p>	<p>Beyond the three years of the project's implementation, Medochemie, FAL Duiven, Athens pharmaceutical, and Catania pharmaceutical will remove the Diclofenac sodium up to 90%, 100.845 g/year</p>	<p>At the end there are 2 pharmaceutical industries which have removed 90% of the pollutant $(0.1 \cdot 58.11 + 0.1 \cdot 84.8 + 325.8 \cdot 2) = 665.891 \text{ kg/y}$ Beyond three years 4 industries will remove the pollutants up to 90%, $(339.4 + 84.8 + 325.8 \cdot 2) \cdot 0.1 = 79.451 \text{ kg/y}$. The concentration of diclofenac sodium in wastewater is 0.118 mg/l. The updated volume of wastewater from the cleaning processes for Medochemie is 2.5 m³/d. So, the initial mass of diclofenac sodium in the production wastewater is 0.118 mg/l or 0.118 g/m³, $0.118 \text{ g/m}^3 \cdot 2.5 \text{ m}^3/\text{d} \cdot 250 \text{ d/y} = 73.75 \text{ g/y}$. Duiven wastewater from the cleaning processes 2.5 m³/d, the initial mass of diclofenac sodium: $0.118 \text{ g/m}^3 \cdot 2.5 \text{ m}^3/\text{d} \cdot 365 \text{ d/y} = 107.7 \text{ g/y}$ Athens and Catania wastewater from the cleaning processes 9.6 m³/d, initial mass of TN: $0.118 \text{ g/m}^3 \cdot 9.6 \text{ m}^3/\text{d} \cdot 365 \text{ d/y} = 413.5 \text{ g/y}$ Removal of diclofenac sodium through the pilot system will be close to 90%. At the beginning: 4 pharmaceutical industries, $73.75 \text{ g/y} + 107.7 \text{ g/y} + 413.5 \text{ g/y} \cdot 2 = 1,008.45 \text{ g/y}$. At the end there are 2 pharmaceutical industries which have removed 90% of the pollutant $(0.1 \cdot 73.75 + 0.1 \cdot 107.7 + 413.5 \cdot 2) = 845.15 \text{ g/y}$ Beyond three years 4 industries will remove the pollutants up to 90%, $(73.75 + 107.7 + 413.5 \cdot 2) \cdot 0.1 = 100.845 \text{ g/y}$.</p>
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6.3 Resource efficiency – Energy

Table 26: Renewable energy production- solar energy

Indicators	Updated Estimated Impact (absolute values) at the end of the project	Updated Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Solar Energy	1,537 kWh/year	8,537 kWh/year	<p>At the end of the project: It is estimated that for the collection and treatment of 1 m³ of wastewater in a WWTP 1 KWh is needed. The PHARMA-DETOX system in Limassol will have the updated capacity to treat approx. 2.5 m³ of wastewater per day. Thus, 2.5 m³/day *250 working days/year=625 m³/year will be treated, and 625 KWh/year will be saved as the system will use energy 100% from RES. At the replication in the Netherlands, the proposed system will treat all the quantity of wastewater produced, about 2,5 m³/day. Thus, 912 m³/year will be treated, and 912 KWh/year will be saved as the system will use energy 100% from RES.</p> <p>In addition, 625 KWh/year+912 KWh/year=1,537 KWh/year will be saved by the operation of the two systems.</p> <p>Beyond 3 years: For the 2 new systems foreseen, it is estimated that will be saved 3,500 KWh/year for each system (we assume 9.5 m³ of wastewater /day). 1,537 KWh/year + 3,500 KWh/year + 3,500 KWh/year = 8,537 KWh / year.</p>

6.4 Resource efficiency – Circular economy

Table 27: Mass of output of waste, number of entities where green circular economy practices are implemented, mass of input of recycled or reused waste, and number of pharmaceuticals products produced.

Indicators	Updated Absolute value at the beginning of the project	Updated Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Mass of output of waste per unit produced (or per mass of unit produced)	0.47 tn/tn unit produced	0.38 tn/tn unit produced	0 tn/tn unit produced	<p>Medochemie Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,182 tn/year Updated Wastewater volume: 2.5 m³/day=625 tn/year FAL Duiven</p>

				Production of final pharmaceutical products (ampoules, caps,tabs,vials): 1,450 tn/year Waste: 2.5 m ³ /day=912.5 tn/year Athens Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Catania Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Recycled waste: start: 0. end: 625 tn/year+ 912.5 tn/year=1,537 tn/year 3 years after 625 tn/year+ 912.5 tn/year+ 3,139 tn/year+ 3,139 tn/year= 7,815.5 tn/year Mass of output of waste/unit produced: unit produced= 5,182 tn/year +1,450 tn/year +5,000 tn/year +5,000 tn/year =16,632 tn/year at the beginning: 7,815/16,632=0.47 at the end: (7,815-1,537)/16,632=0.38 3 years after: (7,815-7,815)/ 16,632=0
Number of entities where green circular economy practices are implemented	0 n. of entities	2 n. of entities	4 n. of entities	Medochemie Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,182 tn/year Updated Wastewater volume: 2.5 m ³ /day=625 tn/year FAL Duiven Production of final pharmaceutical products (ampoules, caps,tabs,vials): 1,450 tn/year Waste: 2.5 m ³ /day=912.5 tn/year Athens Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Catania Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year Waste: 8.6 m ³ /day=3,139 tn/year Recycled waste: start: 0 entities end: 2 entities 3 years after 4 entities
Mass of input of actually recycled or reused waste per unit produced (or per mass of unit produced)	0 tn/tn unit produced	0.09 tn/tn unit produced	0.46 tn/tn unit produced	Medochemie Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,182 tn/year Updated Wastewater volume: 2.5 m ³ /day=625 tn/year FAL Duiven



Production of final pharmaceutical products (ampoules, caps,tabs,vials): 1,450 tn/year
 Waste: 2.5 m³/day=912.5 tn/year

Athens

Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year
 Waste: 8.6 m³/day=3,139 tn/year

Catania

Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year
 Waste: 8.6 m³/day=3,139 tn/year

Recycled waste:

start: 0.

end: 625 tn/year+ 912.5 tn/year=1,537 tn/year

3 years after 625 tn/year+ 912.5 tn/year+ 3,139 tn/year+ 3,139 tn/year= 7,815.5 tn/year

Mass of input of recycled or reused waste/unit produced:

at the beginning: 0

at the end: 1,537/16,632=0.09

3 years after: 7,815/16,632=0.46

Medochemie

Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,182 tn/year
 Updated Wastewater volume: 2.5 m³/day=625 tn/year

FAL Duiven

Production of final pharmaceutical products (ampoules, caps,tabs,vials): 1,450 tn/year
 Waste: 2.5 m³/day=912.5 tn/year

Athens

Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year
 Waste: 8.6 m³/day=3,139 tn/year

Catania

Production of final pharmaceutical products (ampoules, caps,tabs,vials): 5,000 tn/year
 Waste: 8.6 m³/day=3,139 tn/year

Recycled waste:

start: 0.

end: 625 tn/year+ 912.5 tn/year=1,537 tn/year

3 years after 625 tn/year+ 912.5 tn/year+ 3,139 tn/year+ 3,139 tn/year= 7,815.5 tn/year

Number of units produced/year:

at the beginning: 16,632 units

at the end: 16,632 units

3 years after: 16,632 units

Number of units produced/year	16,632 units	16,632 units	16,632 units

6.5 Governance

Table 28: Number of stakeholders involved in the project. Stakeholders are groups, public bodies, organizations, individuals, businesses, manufactures, pharmaceuticals companies, authorities, NGOs etc. that can be affected by the project activities and/or influence their implementation

Indicators	Impact during 09/2021-05/2024	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Public body/bodies: Higher education, General public administration activities	105	100 number of individuals	100 number of individuals	40 + 20 specialists affected by the project activities and influence by their implementation though the 3 rd Verdetech and 11 th International Conference on Sustainable Solid Waste Management Rhodes. Total 45 from previous update+60=105
Private profit: -Water supply; sewage; waste managment and remediation activities -Electricity, gas, steam, and air conditioning supply -Financial and insurance activities -Professional, scientific, and technical activities -Waste treatment and disposal -Manufacture of basic pharmaceutical products and pharmaceutical preparations	105	110 number of individuals	110 number of individuals	50 people from wastewater disposal, water supply industries and sewage waste management, affected by the project activities and influence by their implementation though the 3 rd Verdetech. Total 55 from previous update+50=105

6.6 Information and awareness activities: website and other tools for reaching/raising awareness of the general public

Table 29: Use of website and other tools, such as printed media, videos, events/exhibitions, posters, information boards etc. for reaching and raising awareness to the public

Indicators	Impact during 09/2021-11/2024	Estimated Impact (absolute values) at the end of the project	Estimated impact (absolute values) beyond three years	Brief explanations of assumptions used for the calculations of values indicators
Website	7,328	Number of unique visits: 4,200	Number of unique visits: 7,800	It was reported by Google Analytics that for this period 7,328 unique visits were-conducted.

7. Conclusion

This report covers the period from the start of the project (September 2021) to November 2024 and focuses on changes in key performance indicators. The changes made to the initial PFD for the LIFE PHARMA-DETOX project were related to the recalculation of wastewater production, the adjustment of system operating hours, and ensuring efficient operation and compliance with safety standards. These modifications also updated indicators related to point source pollution and resource efficiency of the project, in particular for energy and circular economy. Other changes during this period were also observed in areas such as the project's impact on people, public information and awareness raising (through the website and social media platforms). A total of 7,997 people were affected by the project's dissemination and awareness-raising activities. This data is based on Google Analytics, which recorded 7,328 unique visits and 519 followers on two social media platforms (Twitter and LinkedIn) and 100 people were influenced by the dissemination of the project at the 3rd Verdetech and 50 people in the 11th International Conference on Sustainable Solid Waste Management Rhodes, Greece.