



LIFE PharmDegrade:

Degradation of pharmaceuticals in wastewaters from  
nursing homes and hospitals

LIFE 13 ENV /SI/000466

## **After-LIFE Communication Plan**



## Project context and aims

The project LIFE PharmDegrade "Degradation of pharmaceuticals in wastewater (WW) from nursing homes and hospitals", took place between September 2014 and November 2016. The main focus of the project were drug residues in WW, which are used in human medicine, further referred as pharmaceuticals.

The main goal of the project was a construction of a pilot wastewater treatment plant (WWTP) with a daily WW treatment capacity of 1,5 – 3m<sup>3</sup> and evaluation of its efficiency in the reduction of pharmaceuticals. The chosen technology of the final step of the sewage treatment was electrochemical oxidation in an electrolytic cell, equipped with boron-doped diamond (BDD) electrodes. In the process, hydroxyl radicals are produced on BDD anode directly from water, which enable nonselective degradation of micropollutants in water.

In addition to the demonstration of the WW treatment, a survey on the occurrence of pharmaceutical residues in different WWs sources (hospitals, nursing homes and WW from households) has been carried out. To appropriately evaluate the quality and quantity of pharmaceuticals in complex water matrices, sample preparation procedures and analytical methods have been optimised during the project (solid phase extraction with liquid chromatography coupled with tandem mass spectrometry).

## Main results

A wider screening of the presence of the pharmaceuticals in the Slovenian environment showed that there were more than 111 pharmacologically active substances found in waters and 35% of them were found at all sampling sites. The majority were medicaments for nervous system and cardiovascular diseases. Their presence in treated water was the same regardless the wastewater treatment stage.

Pilot tests showed promising results in a reduction of the concentration of pharmaceuticals from different pharmacological groups. During the pilot test operation, the following target pharmaceuticals were being analysed in the WW: atorvastatin, bisoprolol, carbamazepine, imatinib, ciprofloxacin, clofibrac acid, diclofenac, fluoxetine, sertraline, and metoprolol. With the applied electrolytic cells equipped with BDD electrodes, we managed to remove on average 80% of pharmaceuticals already after 0,58 seconds of the contact time of the WW with electrodes at 25 mA/cm<sup>2</sup> applied current density. With the extension of the electrolysis, the treatment efficiency increased.

## Future communication activities

### Website

Arhel will further maintain the website, at least three years after the end of the project with its resources. The website will be upgraded with reports on new promotional activities, published results and information for acceleration of commercialization. The website visits will be tracked for better market orientation.

Indicators: more than 50 visits of the website each month; increase the visits from other countries besides Slovenia

### Scientific Publications

At least one more article will be submitted to Peer reviewed journal in 2017 with the results of the pilot plant operation.

Indicators: Published scientific article three years after the end of the project: at least 1.

### Oral scientific communications

Both project partners will regularly track open calls for abstracts of the conferences and fairs to take the opportunity to present project results and promote the technology. The conferences from the following fields will be taken into account:

- Wastewater treatment
- Environmental protection
- Pharmaceuticals and micropollutants in the environment
- Chemical analytics.

Slovenian conferences and scientific meetings will be taken into account, as well as meetings abroad. The visit of the following conferences (not exclusively) is possible:

- Second Slovenian Congress on Water = Drugi slovenski kongres o vodah, 19. – 20. April, 2017, Podčetrtek, Slovenija
- 8th Annual Congress on Analytical and Bioanalytical Techniques Brussels, Belgium August 28-30, 2017
- 12<sup>th</sup> SDEWES Conference Dubrovnik 2017. Conference on sustainable development of Energy, Water and Environment System, 4 – 8 October, Dubrovnik, Croatia.
- 7<sup>th</sup> Croatian Water Conference, 2018, Opatia
- ISSS 2017 23rd International Symposium on Separation Sciences, 19-22 September 2017, Vienna, Austria
- Conference VIVUS, 2018, Naklo, Slovenia
- 4th World Congress on Chromatography, August 7-8, 2017 Rome, Italy
- International IWA Conference on Sustainable Solutions for Small Water and Wastewater Treatment Systems (S2Small2017), Nantes, France
- International conferences on Environmental & food monitoring: ISEAC 40, Santiago de Compostela, Spain, 2018
- Congress of Slovenian toxicology society
- Global Water Summit 2017, Apr. 24-25, 2017, Madrid, Spain
- Watec Israel 2017, Sep. 12-14, 2017, Tel Aviv, Israel, Trade Show/Exhibition,

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- Aquatech Amsterdam 2017, Oct. 31, 2017 - Nov. 3, 2017
- Sustainable Use and Management of Soil, Sediment and Water Resources; 14th International Conference, 26–30 June 2017, Lyon, France

Indicators: Number of the oral or poster presentation on different events in the next three years:  $\geq 5$

## General communication

Four area of communication will be followed:

Arhel will work on:

- Application of electrochemical oxidation as the fourth stage of wastewater treatment to remove micropollutants from municipal wastewater and wastewater coming from centres with higher use of pharmaceuticals (e.g. hospitals, nursing homes) or other micropollutants (waste water: high hydraulic loads, low mass load of pollutants)
- Application of electrochemical oxidation as a wastewater treatment approach for industrial effluents with high contamination load of chemicals and low biodegradability, e.g. wastewater from pharmaceutical industry (wastewater: low hydraulic loads, high mass load of pollutants)
- Application of electrochemical oxidation as in-lake method for cyanobacteria and cyanotoxin control/disinfection purposes (freshwater systems) – in connection with LIFE Stop CyanoBloom project

Faculty of Pharmacy will work on:

- Promotion of simultaneous analysis of different micropollutants from complex water samples with high level of resolution and detection

Potential end users will be addressed by individual company visits and marketing campaigns. Articles will be written for general press and professional journals (some options are: Ekolist, WaterWorld, Water & Wastewater International, The water Network).

Indicators: Number of demonstrations and conversations held:  $\geq 5$ . First commercial reference for electrochemical oxidation system in 2018.

## Other dissemination activities

- Setting up a new collaborative project to continue with the development.
- We will be responsive to LIFE events in Slovenia and EU.
- Connection with Slovenian Chamber of Commerce in further replicability and transferability of the results.
- Presentation of the technological solution at Slovenian Innovation Forum.

## Future plans with the LIFE PharmDegrade pilot plant

It is our strong belief that the research activity should not stop at achieving the LIFE+ goals of the present project. We will put our efforts to continue with the project activities with the emphasis on developing:

- new reliable methods for quantification of the even greater number of bio-hazardous micro-pollutants like the endocrine disruptors and
- new methods for their elimination either at the site of their entering the ecosystem or at the water treatment stage and at the end of production process.

We will look for new financial opportunities for further research and development. After presenting the achieved results, we will start with the presentations of the technology and services at identified end-users (wastewater treatment plants, industries) for the first market replication of the technology. The pilot plant will be offered into test operation to end-users looking for solutions to remove micro-pollutants or other hardly degradable substances from their water. The plant will be offered into use free of charge. The user will cover the operational and needed maintenance costs.

## Dissemination strategy during the project

Preliminary actions	
<b>Logo of the project acronym</b> (used for the website, deliverables, posters, notices and other material associated with LIFE PharmDegrade project)	
<b>Website of the project</b> (to present the project and inform on achieved results with regular updates) <a href="http://www.lifepharmdegrade.arhel.si">www.lifepharmdegrade.arhel.si</a>	
<b>Pilot plant Notice Boards</b>	
Communication with professional and scientific public	
<b>Oral communications</b>	<p>The 6<sup>th</sup> Croatian water conference with international participation, Opatija, Croatia 20 – 23. May 2015</p> <p>21<sup>st</sup> International Symposium on Separation Sciences. June 30<sup>th</sup> - July 3<sup>rd</sup>, 2015 Grand Hotel Union, Ljubljana, Slovenia</p> <p>7<sup>th</sup> Conference Chemical Security for all: medicine drugs in the wastes – dangerous chemicals in the environment). 8. October, 2015, Vetrinjski dvor Maribor, Nacionalni inštitut za javno zdravje.</p> <p>The 4<sup>th</sup> Conference with International Participation. Conference VIVUS – on Agriculture, Environmentalism, Horticulture, and Floristics, Food Production and Processing and nutrition. 20<sup>th</sup> and 21<sup>st</sup> April 2016, Biotechnocal Centre Naklo, Strahinj 99, Slovenia.</p> <p>31<sup>st</sup> International Symposium on Chromatography, August 28<sup>th</sup> - Sept 1<sup>st</sup>, 2016, Cork, Ireland. [Cork]: publisher A. M. Stalcup and J. D. Glennon, 2016, str. 217-218.</p> <p>13<sup>th</sup> IWA Specialized Conference on Small Water and Wastewater Systems [and] 5<sup>th</sup> IWA Specialized Conference on Resources-Oriented Sanitation, 14-17 September 2016, Athens, Greece. Athens: IWA - the International Water Association, 2016</p> <p><i>Symposium 2016 Pharmaceutical Care Network Europe, 19-20 February 2016, Hillerød, Denmark: Conference abstracts</i></p> <p>31<sup>st</sup> International Symposium on Chromatography, August 28<sup>th</sup> - Sept 1<sup>st</sup>, 2016, Cork, Ireland. [Cork]: publisher A. M. Stalcup and J. D. Glennon, 2016, str. 320-321.</p> <p><i>Outstanding solution for a better life</i>, 39<sup>th</sup> International Symposium on Environmental Analytical Chemistry, July 19-22, 2016, Hamburg, (International Conference series on environmental &amp; food monitoring). Hamburg: Hamburg School of Food Science, 2016</p> <p>1. studentski kongres "Hrana - Ishrana - Zdravlje", Sarajevo, 7-9. Juli 2016. godine. Sarajevo: Poljoprivredno-prehrambeni fakultet: = Faculty of Agricultural and Food Sciences, 2016, str. 55-56.</p> <p>LIFE PharmDegrade closure conference, 24. – 25. November 2016, Ljubljana</p>
<b>Posters</b>	<p>2<sup>nd</sup> Congress of Slovenian Toxicology Society: Ljubljana, 23 - 24. April 2015.</p> <p>21<sup>st</sup> International Symposium on Separation Sciences. June 30<sup>th</sup> - July 3<sup>rd</sup>, 2015 Grand Hotel Union, Ljubljana, Slovenia</p>

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	<p>7<sup>th</sup> Conference Chemical Security for all: medicine drugs in the wastes – dangerous chemicals in the environment). 8. October 2015, Vetrinjski dvor Maribor, Nacionalni inštitut za javno zdravje.</p> <p>XI. Mednarodna znanstvena konferenca = XI. International science conference Ekologija za boljši jutri = Ecology for better tomorrow. 31. 03 – 01. 04. 2016. Izobraževalno raziskovalno središče. Rakičan, Murska Sobota.</p> <p>Akademija strojništva 2016. 5. Mednarodna knferenca strojnih inženirjev 2016. INŽENIRSTVO – Sodelovanje industrijskega in akademskega okolja za kakovostnejše življenje Ljubljana Cankarjev dom, 18. Oktober 2016. LIFE Water Platform Meeting. 24. – 25. May 2016, Manchester, UK.</p> <p>31st International Symposium on Chromatography, August 28th - Sept 1st, 2016, Cork, Ireland. [Cork]: publisher A. M. Stalcup and J. D. Glennon, 2016, str. 217-218.</p> <p>13th IWA Specialized Conference on Small Water and Wastewater Systems [and] 5th IWA Specialized Conference on Resources-Oriented Sanitation, 14-17 September 2016, Athens, Greece. Athens: IWA - the International Water Association, 2016</p> <p>Inappropriate prescribing among elderly outpatients in <i>Symposium 2016 Pharmaceutical Care Network Europe, 19-20 February 2016, Hillerød, Denmark: Conference abstracts</i></p> <p>31st International Symposium on Chromatography, August 28th - Sept 1st, 2016, Cork, Ireland. [Cork]: publisher A. M. Stalcup and J. D. Glennon, 2016, str. 320-321.</p> <p><i>Outstanding solution for a better life</i>, 39th International Symposium on Environmental Analytical Chemistry, July 19-22, 2016, Hamburg, (International Conference series on environmental &amp; food monitoring). Hamburg: Hamburg School of Food Science, 2016</p> <p>1. studentski kongres "Hrana - Ishrana - Zdravlje", Sarajevo, 7-9. Juli 2016. godine. Sarajevo: Poljoprivredno-prehrambeni fakultet: = Faculty of Agricultural and Food Sciences, 2016, str. 55-56.</p> <p>LIFE PharmDegrade closure conference, 24. – 25. November 2016, Ljubljana</p>
<p><b>Articles in professional and peer-reviewed journals</b></p>	<p>Published articles in the Proceedings of the LIFE PharmDegrade closure conference: <a href="http://lifepharmdegrade.arhel.si/wp-content/uploads/Zakljucna-konferenca-LIFE-PharmDegrade-20162.pdf">http://lifepharmdegrade.arhel.si/wp-content/uploads/Zakljucna-konferenca-LIFE-PharmDegrade-20162.pdf</a></p> <ul style="list-style-type: none"> <li>- Conference introduction. Maja Zupančič Justin</li> <li>- Pharmaceutical contamination of Slovene wastewaters. Anita Klančar, Jurij Trontelj, Robert Roškar</li> <li>- Development and validation of a semi-automatic LC-MS/MS method for determination of selected pharmaceutical pollutants in wastewater samples. Robert Roškar, Anita Klančar, Albin Kristl, Jurij Trontelj</li> <li>- Toxicity tests for evaluation of pollutant removal from water. Tina Eleršek, Tinkara Rozina</li> <li>- Pilot plant LIFE PharmDegrade: presentation of the plant and its operation with an emphasis on developing electrolytic cell by electrochemical oxidation Gorazd Lakovič, Lovro Pokorn, Luka Teslić, Jošt Grum, Mario Marinović, Marko Gerl</li> <li>- The efficiency of the selected pharmaceuticals' degradation by the new advanced oxidation pilot treatment plant under the LIFE PharmDegrade Project. Jurij Trontelj, Robert Roškar, Anita Klančar, Albin Kristl, Maja Zupančič Justin, Gorazd Lakovič, Maša Čater, Tinkara Rozina, Marko Gerl</li> </ul>

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	<p><b>Published papers in professional and scientific journals:</b></p> <ul style="list-style-type: none"> <li>- An advanced oxidation process for wastewater treatment to reduce the ecological burden from pharmacotherapy and the agricultural use of pesticides. Klančar, Anita, Trontelj, Jurij, Kristl, Albin, Meglič, Andrej, Rozina, Tinkara, Zupančič Justin, Maja, Roškar, Robert. <b>Ecological Engineering</b>, ISSN 0925-8574. [Print ed.], 2016, vol. 97, str. 186-195, doi: 10.1016/j.ecoleng.2016.09.010</li> <li>- Levels of Pharmaceuticals in Slovene municipal and hospital wastewaters: a preliminary study Klančar, Anita, Trontelj, Jurij, Kristl, Albin, Zupančič Justin, Maja, Roškar, Robert. <b>Arhiv za higijenu rada i toksikologiju</b>, ISSN 0004-1254, 2016, vol. 67, no. 2, str. 106-115, <a href="http://hrcak.srce.hr/index.php?show=clanak&amp;id_clanak_jezik=235659">http://hrcak.srce.hr/index.php?show=clanak&amp;id_clanak_jezik=235659</a>.</li> <li>- Simultaneous determination of emerging pharmaceutical pollutants in waste water by solid phase extraction and LC-MS/MS. Anita Klančar, Jurij Trontelj, Robert Roškar. <b>Farmaceutski vestnik 2014. Pharmaceutical journal of Slovenia</b> Special issue 1 – 253. September 2014, Vol 65.</li> <li>- LIFE PharmDegrade project – demonstration of electrochemical oxidation with electrolytic cell as a promising approach to removal of persistent micropollutants in the wastewater treatment process. Maja Zupančič Justin, Tinkara Rozina, Gorazd Lakovič, Lovro Pokorn, Anita Klančar, Luka Teslič, Mario Marinović, Jošt Grum, Jurij Trontelj, Maša Čater, Robert Roškar, Andrey Yakuntsov, Neža Finžgar, Branko Hamiti, Albin Kristl, Marko Gerl. <b>Ekolist 13. Revija o okolju. Inštitut za ekološki inženiring</b>. <a href="http://www.ekolist.si/datoteke/ekolist_13/Ekolist13WEBzarazrez.pdf">http://www.ekolist.si/datoteke/ekolist_13/Ekolist13WEBzarazrez.pdf</a></li> </ul>
<b>Project leaflets</b>	English and Slovenian project leaflets accessible at: <a href="http://lifepharmdegrade.arhel.si/">http://lifepharmdegrade.arhel.si/</a>
<b>Communication with general Public</b>	
<b>Seminars and Workshops</b>	Organised Day of Open Doors at the Pilot plant for public, 25. November 2016 LIFE Slovenia Informative Day at Otočec, Slovenia, 9. August 2016; <a href="https://youtu.be/jLxI6U9MWZc">https://youtu.be/jLxI6U9MWZc</a>
<b>Stakeholders</b>	Meetings with stakeholders of the Steering Committee Group Visits from Serbia and Kosovo municipalities
<b>Exhibitions</b>	Exhibition of the project in the lobby of the Slovenian Ministry of the Environment and Spatial planning; November – December 2016 Exhibition of the project in the frame of the LIFE Slovenia project Info Day, September 16, 2016
<b>Other Press Release</b>	<a href="http://www.sbra.be/sites/default/files/most_issue_57.pdf">http://www.sbra.be/sites/default/files/most_issue_57.pdf</a> <a href="http://znanost.sta.si/2328295/za-zmanjsanje-ostankov-zdravil-v-okolju-potrebna-ustrezna-zakonodaja-in-ozavesenost">http://znanost.sta.si/2328295/za-zmanjsanje-ostankov-zdravil-v-okolju-potrebna-ustrezna-zakonodaja-in-ozavesenost</a> <a href="http://znanost.sta.si/2328092/v-ljubljani-odprli-zaključno-konferenco-projekta-life-pharmdegrade">http://znanost.sta.si/2328092/v-ljubljani-odprli-zaključno-konferenco-projekta-life-pharmdegrade</a>
<b>Interviews</b>	Interview with Slovenian Press Agency: <a href="https://youtu.be/VoAW7iekP4k">https://youtu.be/VoAW7iekP4k</a>
<b>Layman report</b>	On-line Access: <a href="http://lifepharmdegrade.arhel.si/wp-content/uploads/Laymans-Report-LIFE-PharmDegrde.pdf">http://lifepharmdegrade.arhel.si/wp-content/uploads/Laymans-Report-LIFE-PharmDegrde.pdf</a>



## Project participants

Project coordinator

### **ARHEL projektiranje in inženiring d.o.o.**

Application of electronics and informatics in environmental solutions.  
Development of individual solutions with a wide range of applications  
Customer-specific R&D  
Embedded program solutions  
Production and testing of final products  
Serial production  
Turnkey solutions  
Electronics, mechanics and sensors prototype development

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Project partner

### **Chair of Biopharmacy and Pharmacokinetics** **Faculty of Pharmacy, University of Ljubljana**

Know-how support in various phases of drug development and analytics  
Analytical support for various samples  
Pre-formulation and drug stability  
Dissolution and metabolism  
Bioavailability and bioequivalence  
Pharmacokinetic / pharmacodynamic studies  
Therapeutic drug monitoring and personalised therapy  
Pharmacometrics  
Consultancy / Training



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