Project Title:

Water decontamination technology for the removal of recalcitrant xenobiotic compounds based on atmospheric plasma technology

Project Acronym: WATERPLASMA

Grant Agreement Number:

FP7-SME-2010-1 / 262033

Subject:

FINAL PUBLISHABLE SUMMARY

Dissemination Level:

PUBLIC

Project Coordinator:

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PROJECT FUNDED BY THE COMMISSION OF THE EUROPEAN COMMUNITIES UNDER THE COOPERATIVE ACTION OF FRAMEWORK 7

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1. EXECUTIVE SUMMARY

Assuring the quality of water supply is a major concern in Europe, with an increasing awareness about the presence of emerging contaminants in surface waters. One of the main sources of recalcitrant and emerging contaminants is industrial wastewater. Industrial effluents are treated locally prior to discharge to municipal wastewater plants. However, industrial wastewater treatment has become increasingly complex, due to the occurrence of new recalcitrant and highly toxic chemicals in many industrial effluents. In such cases, treatments based on physico-chemical or biological processes are not sufficient, forcing industries to outsource the treatment of their wastewater, thus leading to high disposal costs. It has been estimated that SME companies from the fine chemicals sector invest up to 5% of their budget in complying with waste disposal laws.

Waterplasma was conceived as a solution for sectors such as the chemical, pharmaceutical of polymer industries, which require new efficient and cost-effective water decontamination technologies to remove xenobiotic compounds. With a total duration of 2 years, Waterplasma not only has demonstrated the efficiency of one atmosphere uniform glow discharge (OAUGD) plasma for the removal of a wide range of recalcitrant and toxic molecules, but it has scaled-up the technology to pilot plant level and proved its treatment capacity under continuous flow conditions.

The development of the Waterplasma project has promoted the cooperation between 4 SMEs f and 3 RTDs from different EU countries in a multidisciplinary team with the common objective to provide a solution to a global problem.

The Waterplasma pilot plant was successfully started up in June 2012, after which it was extensively tested to optimize its performance under a wide range of conditions. Two main scenarios were tested in the Waterplasma pilot plant. The technology was first tested for the removal of recalcitrant and emerging contaminants at low concentration levels in distilled water, where it proved its best efficiency (between 50% and 99% removal depending on compound). The efficiency of Waterplasma was subsequently tested for the treatment of highly loaded industrial wastewater (COD~10,000mg L^{-1}). The need for longer contact times was assessed, and the effect of process variables such as pH on the degradation efficiency was also studied. Removal rates of around 25% were achieved with raw wastewater, while pH control was found to significantly improve the removal efficiency. Further investigation should be undertaken to assess the potential benefits of controlling different process parameters for the treatment of complex wastewaters.

The results yielded by the Waterplasma project have proved the great potential of atmospheric plasma technology for the removal of recalcitrant contaminants from tertiary effluents or even drinking water. The efficiency of the system declines when the target contaminants are dissolved in wastewaters highly loaded with organic matter. However, the exploitation board intends to study the use of Waterplasma in combination with other oxidation technologies, either as pre-treatment or post-treatment, to provide a complete solution for industrial wastewater treatment.

2. SUMMARY DESCRIPTION OF PROJECT CONTEXT AND OBJECTIVES

Different Advanced Oxidation Processes, as well as the combination of two or more of them in order to enhance oxidative effects by means of synergistic effects, are currently under investigation. Fenton's reaction[i], the catalytic decomposition of hydrogen peroxide into hydroxyl radicals by metal ions, and the corresponding photo-Fenton reaction where UV light initiates the peroxide decomposition, have been utilised for water treatment. Photochemical methods including photolysis, photocatalysis and UV/ozone/hydrogen peroxide *(Peroxone)* have also been the subject of recent interest. Ultrasound, supercritical oxidation, catalytic oxidation, thermal oxidation *(thermal incineration)*, and direct electrochemical reactions have been studied.

The main aim of Waterplasma was to overcome the major limitations of existing methods for the removal of recalcitrant compounds from water. No efficient cost effective technology exists for such a purpose, and therefore, the development of a One Atmosphere Uniform Glow Discharge (OAUGD) plasma based pilot plant constitutes a major innovation with respect to existing water treatment methods.The potential of OAUGD was proven at laboratory scale, although no commercial plasma reactor for this purpose existed at the moment.

Project objectives

The main goal of the *Waterplasma* project was to scale-up an Advanced Oxidation Process *(AOP)* based on the use *OAUDG* plasma technology, given the promising results obtained at laboratory scale for the removal of recalcitrant xenobiotic compounds often present in industrial wastewaters.

The following objectives were defined:

- Development of a three-phase (gas, liquid, plasma) OAUGD plasma reactor that can process up to 250 $L\ h^{-1}$ of wastewater in continuous flow regime, reducing the concentration of targeted recalcitrant compounds by 90%.
- Development of the power electronics allowing the application of a high-frequency, high-voltage signal between the two reactor electrodes.
- Construction of a pilot plant where of all previous elements will be integrated in a fully functional, autonomous pilot plant. Water and gas management instrumentation will be provided, and a control system will be developed to allow the autonomous and safe operation of the Waterplasma pilot plant.
- Identification and subsequent optimization of the relevant variables related to reactor performance using laboratory-synthesized wastewater.
- Validation of the technology in an industrial demonstration sites with real industrial wastewater.

* The reactor costs should be kept below **€60k** and operational costs should not exceed **2€ m^{-3}** to ensure competitiveness of the technology.

3. DESCRIPTION OF MAIN S&T RESULTS/FOREGROUNDS

Starting in January 2011, the Wateplasma project had a total duration of 2 years. The project workplan was organized in Work Packages, consisting of different tasks that allowed the progressive advancement towards the achievement of the project objectives.

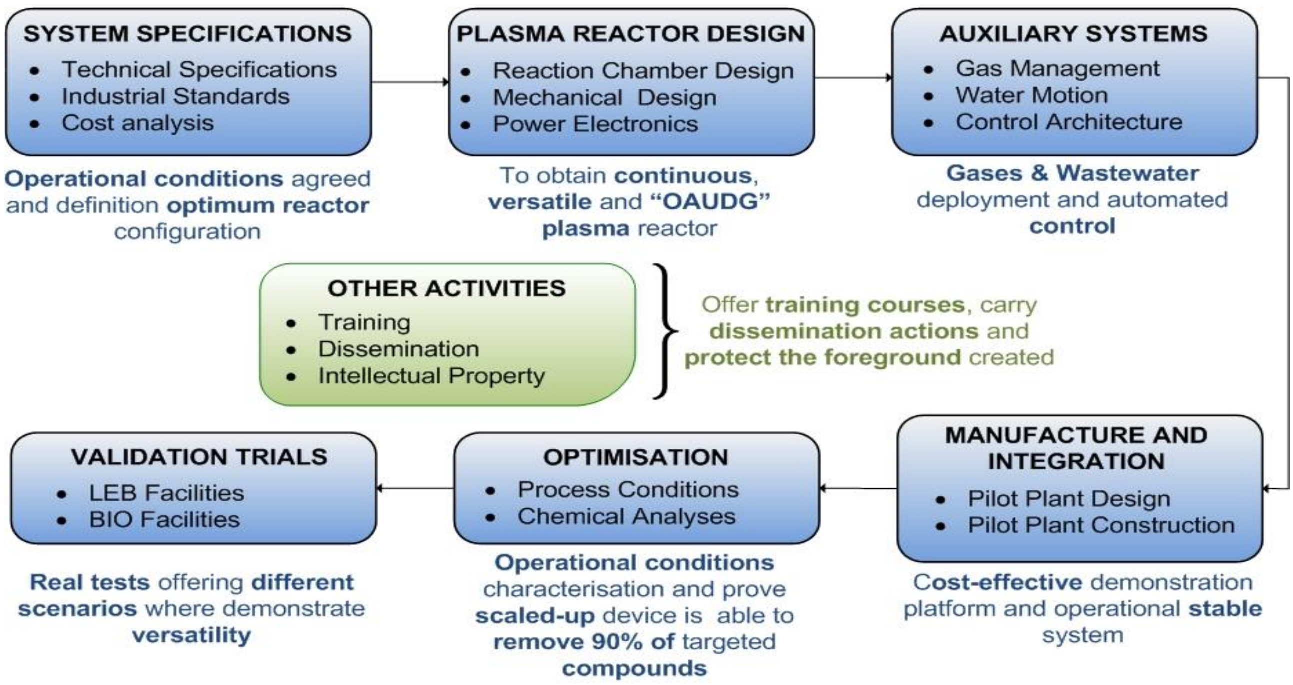


Figure 1: Identification of the main tasks to be carried out in order to achieve the different project objectives.

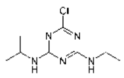
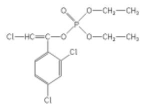
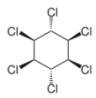
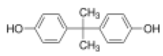
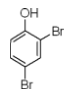
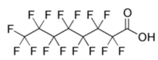
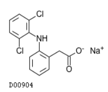
WP1: System specifications

Several European directives exist in relation to the control of the characteristics of industrial water effluents. Directive 91/271/EEC specifies maximum limits for BOD5, COD and suspended matter in industrial wastewater. The Integrated Pollution Prevention & Control (IPPC) directive 2008/1/EC, which regulates the chemical industrial sector, provides an indicative list of water pollutants and defines quality standards based on "Best Available Techniques".

The Water Framework directive 2000/60/EC includes a list of hazardous contaminants and of priority substances, which is under constant review. However, the implementation of these directives may differ in the different EC countries, which will develop their own regulations based on these general directives.

A list of representative contaminants was identified, which were used as target compounds to test the performance of the Waterplasma technology. The list includes both ***EU targeted priority pollutants*** and other ***emerging contaminants*** like pharmaceuticals, due to the increasing awareness detected by SMEs in attended events where the Waterplasma technology was disseminated.

Table 1 Contaminants evaluated in the DBD plasma reactor at the IQAC–CSIC facilities. *The relevant directives that define the priority contaminants are Directive 2000/60/EC, Directive 2008/105/EC; n.a.: not applicable.

NAME	pK_a	log K_{ow}	Water solubility (mg L^{-1}) 25ºC	Boiling Temp (ºC)	Henry's ctant. (Pa m^3 mol^{-1})	Vapor Press. at 25ºC (Pa)	ID nr in priority list*	Molecular structure
Atrazine CAS 1912-24-9 Molecular mass 215.69	pKa_1 1.60; pKa_2 1.95	2.61	34.7 at 26ºC	313.03 (c)	2.39×10^{-4}	3.85×10^{-5}	3	
Chlorfenvinfos CAS 470-90-6 Molecular mass 359.58	-	3.81	124	397.78 (c)	2.93×10^{-3}	1.00×10^{-3}	8	
Lindane CAS 608-73-1 Molecular mass 290.83	-	3.72-4.14	0.24-31.4	304.35 (c)	5.21×10^{-1}	4.69×10^{-3}	18	
Tributhyltin-hydride CAS 58-89-9 Molecular mass 291.07	-	4.10	4.361 (b)	250 (c)	1.54×10^{5}	5.31 (e)	30	
Bisphenol-A CAS 80-05-7 Molecular mass 228.29	9.59-11.30	3.32	120	363(c)	9.28×10^{-7} (d)	3.03×10^{-5} (e)	n.a.	
Free cyanide CAS 57-12-5 Molecular mass 27.03	9.3	-0.25	1×10^{6}	25.6	2.46×10^{3}	9.89×10^{4}	n.a.	CN^-
2,4-dibromophenol CAS 615-58-7 Molecular mass 251.91	7.79	3.22	1900 at 15ºC	238	9.02×10^{-3} (d)	2.14 (e)	n.a.	
Pentadecafluorooctanoic acid CAS 335-67-1 Molecular mass 414.07	0.35	4.81 (a)	0.4813 (b)	192	9.20×10^{3}	7.00×10^{1}	n.a.	
Diclofenac CAS 15307-86-5 Molecular mass 296.15	4.15	4.51/ 0.7	4.52	423.77 (b)	4.80×10^{-7} (c)	8.19×10^{-6} (d)	n.a.	

WP2: Plasma reactor design

Different bench scale prototypes, with planar and coaxial designs have been used for laboratory testing throughout the project. The coaxial configuration was chosen as the most adequate for scale up, due to the lower footprint in relation to the required electrode surface area.

The most adequate materials for the construction of a pre-competitive prototype were chosen. The electrodes, as well as the interface with the water and gas supply system were designed.

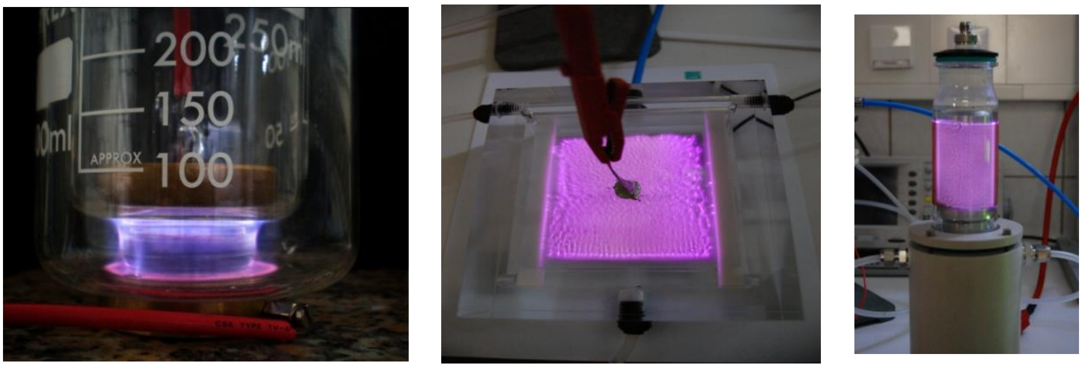


Figure 2: Three different set-ups used for bench-scale testing.

Based on the results obtained at laboratory scale, the scale up factor for the power generator was estimated. The new generator had the following specifications:

- Voltage variable between 0 and 20 kV
- Output Power maximum at 2 kW
- Frequency variable between 10 and 80 kHz
- Input voltage 220 V, input power ca. 2.2 kW

WP3: Development of auxiliary systems

The objective of Work Package 3 was the development of the auxiliary systems needed to ensure the correct performance of the Waterplasma prototype, including water and gas management as well as the design of the control system guaranteeing the autonomous and safe operation of the pilot plant. The designed auxiliary systems were designed in such a way that they provide the required flexibility to allow operation under a wide range of conditions during subsequent reactor optimization and industrial validation.

The water impulsion system was dimensioned according to system specifications (a processing capacity of up to 250 L h^{-1} was established). To provide the prototype with further flexibility as a test rig, the prototype was provided with the capacity for recirculation of the treated wastewater.

The gas injection unit allowed the regulation of the composition and total gas flowrate independently by means of mass flow controllers. The gas injection system was designed in such a way that complete gas mixing was achieved and homogeneity in the distribution inside the reactor was maximized.

The sensors for the monitoring of the relevant process variables were defined and a control strategy was defined based on the identified control needs.

The control system (including the development of the control software) allows automation of the Waterplasma pilot plant operation and complies with the following functions:

- Continuous monitoring of process variables: pH, conductivity, temperature, pressure
- Control of the main process units (pumps, plasma generator, electrovalves)
- Set point definition
- Logging process data and alarm events into a database (MySQL)
- Visualization of data logged into the database (historical alarms and process data) in tables or graphs.
- Off-line data management

The user interface allows easy monitoring and control of the process from a single screen, which integrates all main process elements (**¡Error! No se encuentra el origen de la referencia.**). The control system allows operation in both manual and automatic mode. The operation mode selection can also be selected from the main screen, facilitating start up or maintenance procedures.

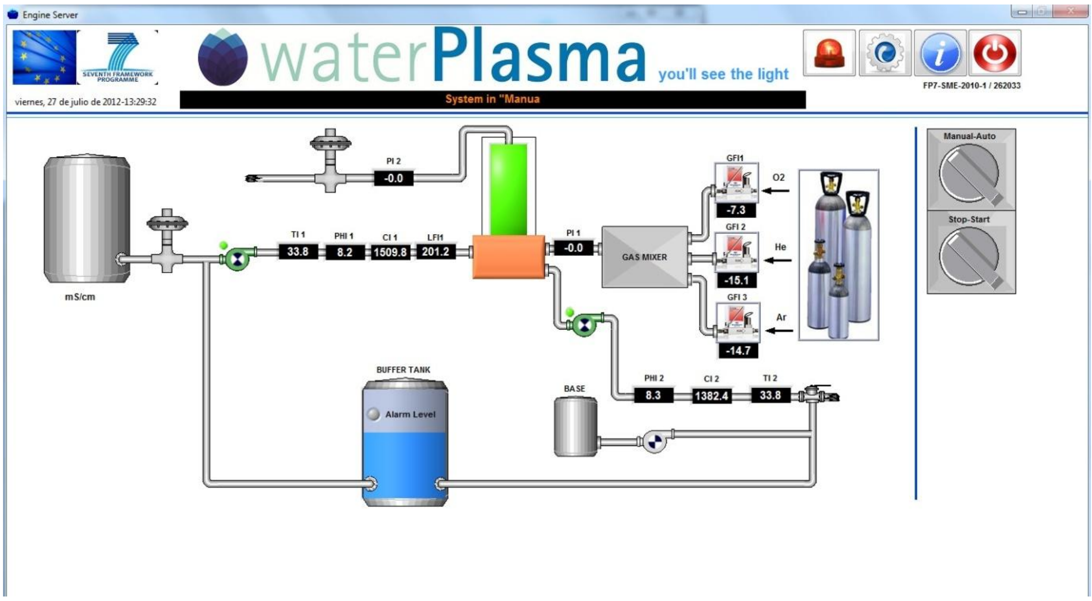
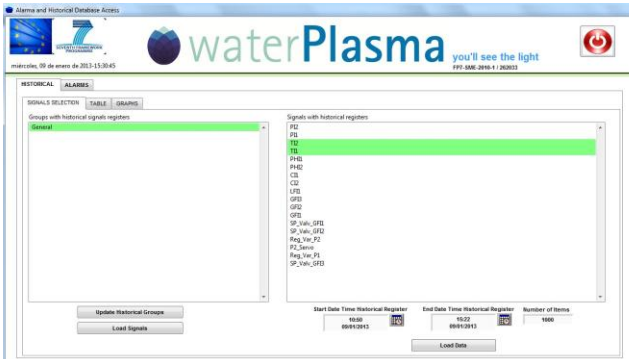
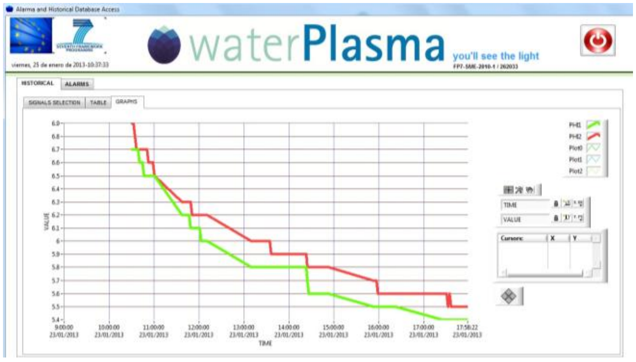


Figure 3: Waterplasma user interface during system operation in manual mode





WP4: Reactor manufacturing and integration

The tasks in WP4 involved the design and construction of the pilot plant that integrates the Waterplasma reactor and the auxiliary systems and control system required for its autonomous and safe operation. The reactor, services, monitoring and control instrumentation were integrated in a compact unit transportable for demonstration purposes. The control cabinet containing all connections and modules interfacing with the sensors and actuators is attached to the main prototype structure (Figure 4). Finally the electrical interface between the plasma generator and the reactor was provided and power connections and interface with the control system were implemented for all instrumentation elements.

Figure 4: Electrical control cabinet

The pilot plant was successfully started up and fully operative for testing in June 2012 (Figure 5).

Figure 6: Wateplasma pilot plant in operation

WP5: Optimization

The degradation kinetics of the the target pollutants was assessed by means of batch experiments carried out in three different bench-scale prototypes.

Following the experiments carried out at bench scale, an extensive optimization of the operational conditions was undertaken in the Waterplasma pilot plant. Preliminary experiments carried out using azo-dye methylene blue as a reference molecule led to the identification of the most relevant parameters affecting the plasma treatment. The following variables were studied:

- Total gas flowrate
- Total water flowrate
- Gas composition
- Electrical conditions (frequency, duration of pulses, output voltage and power)

The selected operational variables were optimized by multivariate statistical techniques in the pilot scale reactor and finally the removal of specific recalcitrant compounds and also the mineralization of COD/TOC from industrial wastewaters were tested extensively. The toxicity of different wastewaters was studied before and after treatment with Waterplasma in order to evaluate the removal efficiency of toxic components and the formation of intermediates that might increase the toxicity of treated water.

A search for specific related intermediates was executed during the tests with laboratory synthesized wastewater, using state of the art analysis methods at CSIC facilities. Operation of the system both in continuous flow and recirculation conditions was tested.

A good efficiency was obtained in the removal of recalcitrant and emerging contaminants at low concentrations (~1 mg L^{-1}) from distilled water (Figure 7).

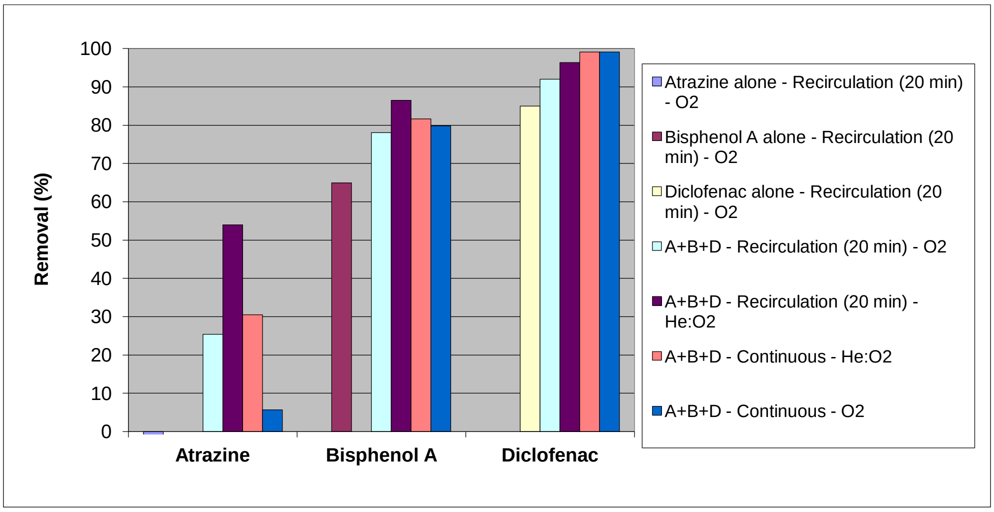


Figure 7: Removal of the target xenobiotics in the reactor. *Conditions*: water flow 50 L h^{-1}, gas total flow 1400 mL_n min^{-1}, 20kV.

WP6: Industrial validation

The industrial validation of the Waterplasma pilot scale prototype was carried out between November and December 2012 using industrial wastewater from two end users:

- Chemo-pharmaceutical industry: LEBSA (Cornellà de Ll., Barcelona, Spain)
- Bio-pharmaceutical industry: BIOTEHNOS (Bucharest, Romania)

Figure 8: Waterplasma prototype in operation with industrial wastewater from LEBSA

The performance of the Waterplasma prototype was tested on highly industrial wastewater using pure O_2 as plasma gas, with slightly different results with the waters from the two demonstration sites.

- ***BIOTEHNOS wastewater*** **(TOC~110 mg L^{-1}, pH~7):** up to 73% mineralization was achieved, and the toxicity analysis showed no increase due to the presence of intermediate species, working in continuous flow regime up to 50 L h^{-1}. Further increase of the treatment time by operating the reactor in recirculation mode (20min treatment for 10L) led to 100% mineralization and the toxicity was completely removed.

- ***LEBSA wastewater** (TOC~1945 mg L^{-1}, pH~5)*: mineralization was not achieved when the reactor was operated in continuous mode. Under recirculation mode (20min/10L) ***22% TOC reduction*** was achieved and toxicity remained within the same range. The addition of Helium to the plasma gas mixture did not increase the removal efficiency and thus it was discarded due to its high price. Further increase of the contact time did not increase removal efficiency, although it was observed that by adjusting the initial pH of the sample the degradation was significantly enhanced.

The final specifications, in terms of treatment capacity and operational costs, for the application of the technology in different scenarios were defined. For clean waters containing only small concentrations of recalcitrant or emerging contaminants, a high removal efficiency was achieved in continuous flow regime with water flowrates up to 120 L/h. In the case of industrial wastewaters with high organic loads, the required contact time was much higher, and further optimization of process parameters (e.g. pH) has to be undertaken to guarantee a cost-efficient treatment.

Table 2: Treatment capacity limits for atrazine, bisphenol A and diclofenac in clean water

Parameter	Atrazine	Bisphenol A Diclofenac
Water flow (continuous)	50L h^{-1}	50-120 L h^{-1}
Gas mixture	O_2:He	O_2
Initial concentration (mg L^{-1})	~1	~1
Removal efficiency	~30%	80-99%

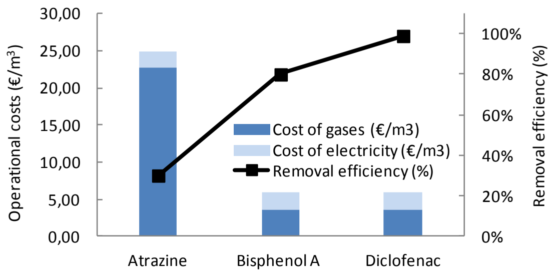
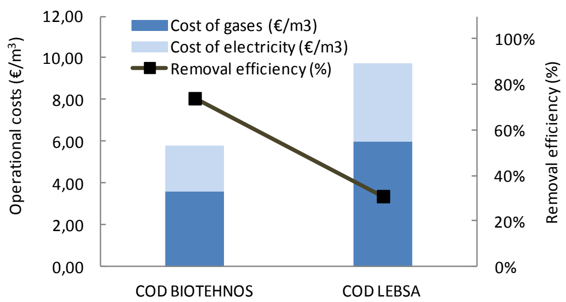


Table 3: Treatment capacity for highly loaded wastewaters (TOC removal). *Experiments carried out with initial pH adjustments suggest substantial improvement with pH adjustment, allowing operation under continuous flow regime (50 L h^{-1})

Parameter	LEBSA	BIOTEHNOS
Water flow (continuous)	Batch (20min, 10L)*	50 L h^{-1}
Gas flowrate (mln min^{-1})	~1500	~1500
Gas mixture	O_2	O_2
Initial TOC (mg L^{-1})	~2000	~110
Removal efficiency	22%	73%



Main conclusions, improvements and recommendations for industrialization

The potential of Waterplasma for the degradation of recalcitrant compounds from water under continuous flow regime has been demonstrated at pilot scale with representative priority compounds (atrazine, bisphenol A) and emerging contaminants like antiobiotics (Diclofenac). For Bisphenol A and Diclofenac high degradation efficiency was achieved at up to 50 L h^{-1} for bisphenol A and 120 L h^{-1} for diclofenac.

Atrazine proved to be more resistant to the plasma treatment, and the best results were achieved by adding He to the plasma gas mixture and operating the reactor in batch. Under these conditions removal efficiencies up to 50% were achieved although the longer time and use of Helium significantly increase the operational costs. Further optimization of the operation conditions (e.g. pH control, etc) should be tested in order to increase efficiency, as well as the use of catalyzers like TiO_2 to enhance the UV effect of the plasma treatment.

Waterplasma was subsequently tested as a secondary treatment for the removal of COD from highly loaded industrial wastewater.

- The treatment was efficient for wastewater with moderate COD concentrations (approx. 500 mg L^{-1}), achieving mineralization of up to 73% of the organic content under continuous flow conditions at 50 L h^{-1}. The tested water (from end user BIOTEHNOS) had previously been submitted to membrane filtration to decrease the concentration of phenol.
- Highly loaded wastewaters presented higher resistance to degradation. The tested water had a COD of approx. 7000 mg L^{-1} and a pH=5. The best degradation results were achieved in recirculation mode, with efficiencies up to 22%. The effect of pH was investigated and it was concluded that the adjustment of pH to a value close to pH=7 substantially increased the degradation of COD. However, an exhaustive and statistically reliable study should be carried out in the future to characterize the effect and relate it to the different compounds present in the sample, which were unknown in the tested wastewater.

Further improvements that would potentially increase the efficiency of the reactor and represent a further step towards industrialization have also been identified during the demonstration phase. These include an improvement of the materials selection and reactor configuration that would allow higher homogeneity of plasma using O_2 while increasing the robustness of the reactor.

The results obtained from testing the prototype under two very distinctive scenarios, suggest that the Waterplasma technology has a great potential to compete with other AOPs.

4. POTENTIAL IMPACT, MAIN DISSEMINATION ACTIVITIES AND EXPLOITATION OF RESULTS

Potential impact of Waterplasma

The exploitation board has estimated that there are around 95,000 chemical companies in the EU currently requiring local wastewater processing facilities. A percentage of 46% have been identified as being in the countries covered by the consortium members although a more conservative estimation of the market share would be around 4%. This leads to a potential market size of €225M for this system. Other non participant countries also offer a significant potential market, since France, Italy and The Netherlands represents 31% of the European market, thus further business is foreseen.

Two possible scenarios for exploitation of the Waterplasma technology were identified:

- **Consumption water**: Waterplasma may be used as a quaternary process or else for public consumption waters, after standard pre-treatment procedures and before being delivered to main distribution networks. In either cases, the plasma effect would be reinforced and efficiency maximized by the fact that only the targeted molecules would be present in the water, allowing the oxidizing potential of the technology to be fully applied to remove xenobiotic compounds, as pretended, and maximizing the effectiveness at a lower running cost.
- **Industrial wastewater**: the high efficiency demonstrated by plasma in breaking complex molecules at acceptable energy consumption rates, points towards the possibility to use Waterplasma as a pre-treatment or polishing step for industrial wastewater, in combination with other well-known oxidation techniques such as electro-oxidation or electrocoagulation, providing the best combined process for industrial wastewater treatment.

The consortium SMEs that plan to become directly involved in the exploitation of the Waterplasma technology have devised an overall plan for exploitation based on the following premises:

- Technical SMEs have the capacity to lead the exploitation of the new technology by manufacturing, marketing and distributing the Waterplasma system.
- End user SMEs (manufacturers of chemo- and bio- pharmaceutical products) will not directly participate in the exploitation.

Dissemination activities

Dissemination at different levels (scientific community, end users of the technology and general public) was reached through different dissemination platforms, including the publication of results in scientific journals, technical journals and other specialized media, dissemination of the project through business networks, digital media or conferences and trade fairs of the specialized sectors.

The dissemination strategy was enhanced by the maintenance of a public website (http://www.waterplasma.eu) which was set up and is maintained by IPE.

The consortium also decided to take profit of the impact of social networks by creating Waterplasma profiles for LinkedIn, Facebook and YouTube.

http://www.twitter.com/waterplasma

http://www.youtube.com/user/waterplasma

http://www.linkedin.com/groups/WATERPLASMA-3983200?home=&gid=3983200&trk=anet_ug_hm

Figure 9: Waterplasma commercial poster (left) and roll up (right) design used in dissemination activities during the project

A summary of the main activities carried out during the project can be seen in the following tables.

Table 4: List of submitted/published publications related to the Waterplasma project, including scientific publications and diffusion in the general media.

SCIENTIFIC PUBLICATIONS	
SITE	**DETAILS**
Critical Reviews in Environmental Science and Technology	*Scientific article in peer-reviewed journal* Chemical decontamination of water by using atmospheric pressure nonthermal plasma: A review. María Hijosa-Valsero, Michael Müller, Ricardo Molina, Anna Montràs, Josep M. Bayona. Critical Reviews in Environmental Science and Technology. (*Status:* under review, sent on 29-June-2012).
Water Research	*Scientific article in peer-reviewed journal* Removal of cyanide from water by means of plasma discharge technology (2013) María Hijosa-Valsero, Ricardo Molina, Hendrik Schikora, Michael Müller, Josep M. Bayona. Water Research Volume 47, Issue 4, Pages 1701-1707 (*Status*: Published) http://dx.doi.org/10.1016/j.watres.2013.01.001
To be defined	*Scientific article in peer-reviewed journal* Removal of priority pollutants from water by means of plasma discharge technology. María HijosaValsero, Ricardo Molina, Hendrik Schikora, Michael Müller, Josep M. Bayona (Status: in preparation).
12th European Plasma Conference	*Talk* Decomposition of dissolved organic contaminants by atmospheric dielectric barrier discharge plasma above flowing water layer. M. Müller, H. Schikora, A. Montràs, J. Álvarez, M. Hijosa-Valsero and JM Bayona. *http://www.htpp12.com/*
Conference EcoImpuls 2012	*Poster presentation.* Decomposition of dissolved organic contaminants by atmospheric dielectric barrier discharge plasma above a flowing water film. M. Müller, H. Schikora, M. Hijosa-Valsero, R. Molina, A. Montràs, M. Constantinovici and JM. Bayona. *http://www.eco-impuls.ro/conference-eco-impuls-2012/*
13th International Conference of Plasma Surface Engineering	*Poster presentation:* Interaction of atmospheric dielectric barrier discharge plasma above flowing water with dissolved organic contaminants. M. Müller, H. Schikora, A. Montràs, J. Álvarez and M. Hijosa-Valsero. *http://www.pse-conferences.net/pse2012.html*
16. Fachtagung für Plasmatechnologie	Using a DBD above flowing water in order to remove dissolved organic contaminants. M. Müller, H. Schikora, J. Barz, C. Oehr, M. Valsero, A. Montras, R. Molina and J. Bayona. *http://www.pt-16.org/pt16/*
GENERAL MEDIA	
Cornellà Informa	**Cornellà, Spain (May-June 2012):** Local media inform on the joint effort of two (LEBSA, CRIC) Cornellà (Spain) local companies as part of the Waterplasma consortium.
Expansión	**Spanish,** Article published 14th November 2012
El Mundo 'Innovadores'	**Spanish**, Article published on 27th November 2012
La Vanguardia	**Spanish**, Article published on 9th December 2012

www.construnario.com	**Spanish**, Online publication *Online publication 20th November 2012* *http://www.construnario.com/notiweb/38684/cornella-sede-de-un-revolucionario-proyecto-europeo-para-depurar-aguas-industriales*
www.interempresas.net	**Spanish**, Online publication Online publication, 13th November 2012 *http://www.interempresas.net/Equipamiento_Municipal/Articulos/102285-Cornella-sede-de-un-revolucionario-proyecto-europeo-para-depurar-aguas-industriales.html*

Table 5: Main dissemination platforms of the Waterplasma technology during the project.

EVENTS	
SITE	**DETAILS**
APIFARMA meeting 2011	APIFARMA meeting and Pharmaceutical lobby meeting Portugal : October 2011 http://www.apifarma.pt/Paginas/default.aspx
AQUATECH 2011	Process, Drinking and Wastewater trade fair Amsterdam, NL: 1st-4th November 2011 http://www.aquatechtrade.com/amsterdamen/Pages/default.aspx
POLLUTEC HORIZONS 2011	Paris, France: November 2011 http://www.pollutec.com/
IWEX Water Live 2012	Birmingham, UK: 22-24th May 2012 http://www.edie.net/whatson/view_event.asp?id=4298
Everything About Water (EAW)	New Delhi, India : 9-11th February 2012 http://www.eawater.com/
Smart City Expo 2011	Barcelona, Spain: 29th November – 2nd December 2011 *http://www.smartcityexpo.com/2011-edition*
Radio Cornellà	**Cornella, Spain June 2012**: interview on local radio. LEBSA and IPE discuss the benefits of the Waterplasma project for local companies LEBSA and IPE as well as the impact at EU scale.
12th European Plasma Conference	Bologna, Italy, 24th -29th June 2012 *http://www.htpp12.com/*
Conference EcoImpuls 2012	Timisoara, Romania 26th October 2012 *http://www.eco-impuls.ro/conference-eco-impuls-2012/*
4th European Exhibition of creativity and innovation	Iasi, Romania 10-12th May 2012 http://www.eudirect.ro/euroinvent/index.html
13th International Conference of Plasma Surface Engineering	Garmisch-Partenkirchen, Germany 10th-14th September 2012

	http://www.pse-conferences.net/pse2012.html
Waste Management Pharmaceutical / Drugs as Emerging Contaminants: Present and Future Prospects	Lisboa, Portugal 19th April 2012
IFAT	Munich, Germany 12th -17th May 2012 http://www.ifat.de
The Quarterly Meeting of the Autonomous Commission for Safety and Hygiene in the Spanish Chemical Industry (COASHIQ)	Cornella de Llobregat Spain, 02-10-2012 Event organized by LEBSA. Representatives of the Spanish pharmaceutical sector were explained the advantages and potential of the Waterplasma technology.
16th Fachtagung für Plasmatechnologie	Greifswald, Germany 18th-23rd February 2013 http://www.pt-16.org/pt16/index.php?id=146

The Waterplasma consortium

Ventilaqua Tratamento de Águas e Efluentes Lda.
(www.ventilaqua.com) - COORDINATOR

Plasma Clean Limited
(www.**plasma-clean**.com)

Laboratorios Espinós y Bofill, S.A. (LEBSA)
(www.lebsa.com)

S.C. Biotehnos S.A.
(www.bth.ro)

Centre de Recerca i Innovació de Catalunya S.A.
(www.cric.cat)

Fraunhofer Gesellschaft Zur foerderung Der Angewandten Forschung E.V.
(www.igb.fraunhofer.de)

Agencia Estatal Consejo Superior de Investigaciones Científicas
(www.csic.es)

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