Mid-Term Progress Report

Water Joint Programming Initiative
2018 Joint Call

Closing the water cycle gap - Sustainable management of water resources

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MANAGED AQUIFER RECHARGE: ADDRESSING THE RISKS OF RECHARGING REGENERATED WATER

MARAadentro

This document must be filled in by the project coordinator with the help of its project partners and must be sent to the WaterWorks2017 Follow-up Secretariat by **31 October 2020** (for Consortium PCI2019-103603)**.**

The WaterWorks2017 Follow-Up Secretariat will ensure distribution to the concerned national funding agencies. The project coordinator is responsible for sending a copy of the report to its partners.

PROJECT TITLE AND ACRONYM

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Project Website: www.maradentro-jpi.eu
Project code: WaterWorks2017- MARAadentro

Duration of project: 36 months
Start date: 17 May 2019

End date: 16 May 2022

Period covered by this report: 17 May 2019 – 16 October 2020

1. Publishable Summary *(Maximum 1 page)*

Project context and objectives. The severe shortage of water reserves is a global problem that will increase with a growing world population and climate change. Managed Aquifer Recharge (MAR) contributes to replenish depleted aquifers and restore ecological services in freshwater ecosystems. However, risks associated with the occurrence of pathogens and contaminants of emerging concern (CECs) in groundwater led to questioning using regenerated water for MAR.
MARadentro (www.maradentro-jpi.eu) aims to lower the pressure on water resources through (i) the evaluation of the risks associated with the use of regenerated water in MAR and (ii) the identification of proper requirements to ensure human health and environment protection, feasibility, and public confidence in the use of regenerated water in MAR. We will enhance water quality improvement in MAR through reactive barriers to stimulate CECs degradation and pathogen inactivation. The CECs occurrence data will allow performing an environmental risk assessment through modeling tools to test the environmental impact of the proposed MAR. We will also evaluate the operational and economic feasibility of upscaling lab tests to a pilot MAR and a real field MAR. Finally, we will transfer the knowledge gained and provide recommendations for efficient implementation and operation of MAR, and to help for an EU regulation on MAR.

Main results so far. The occurrence of microbial and CECs was reviewed together with relevant processes affecting their transport and fate in MAR. The information provided was used to tailor the experimental design of the project to improve the overall performance (e.g., the selection of barrier materials to be tested in batch studies, the role of plants according to the species, and the selection of chemical and microbiological contaminants of interest). Batch experiments were performed to test the capability of the eleven selected barrier materials to adsorb the previously agreed contaminants of emerging concern Adsorption capacity, hydraulic parameters, and organic carbon release capacity were determined. A collaboration agreement was signed between IDAEA and Consorci de la Costa Brava (CCB) for the installation of MARadentro in the WWTP of Palamós (Girona). In this framework several recharge periods have been accomplished. Sampling campaigns were organized during the recharge periods in June-July 2019, January-June 2020, and July-August 2020. Analyses are still in process. Preliminary results were achieved on the relative abundances of functional groups responsible for transformation of nitrogen compounds, and a method was developed for DNA extraction from woodchips material. Modelling tools for behaviour and risk prediction of selected contaminants have been developed as well. The geotechnical study of the tentative WWTP to install the field MAR has been performed.
Kick-off and project meetings have been celebrated. End-users meeting celebrated with satisfactory feedback. Several dissemination activities were carried out (ex. webpage, mass media, Masters, meetings).

Expected final results and their potential impact and use. Overall, MARadentro will fill knowledge gaps for MAR technology to contribute to closing the water cycle gap. The identification of the suitable composition of reactive barriers and the design at real scale will promote MAR as a sound technology, capable to increase freshwater resources improving the ecological status and chemical quality of groundwater while ensuring no negative impacts over human health. The economic analysis of the MAR prototype will facilitate the comparison with other wastewater reclamation systems as well as guide market MAR replication. Key recommendations will be formulated, under stakeholder's guidance, to help develop water policies closer to end-users needs and acceptable by citizens.

2. Work Performed and the Results achieved during the reporting period

Deliverables produced and related information are attached

a. Scientific and technological progress

Progress on objectives and milestones and deliverables status

The project has progressed towards the objectives stated, and milestones were achieved in most cases (**Table 1**). However, the difficulty to perform field and laboratory experimental work when programmed, due to the COVID-19 pandemic, delayed the achievement. This is further discussed along the document.

Table 1: Milestones and deliverables (in green) in the reporting period.

Month		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
WP 1	M	1	2							3									4
	D	1																	
WP 2	M				1														
	D							1											
WP 3	M		1	2		3						4		5					
	D						1			2							3		
WP 4	M													1			2		
	D																		
WP 5	M					1							2						
	D						1							2					
WP 6	M																		
	D																		
WP 7	M																		
	D																		
WP 8	M					1													
	D					1													

Below is the list of milestones and deliverables. Those highlighted in grey are being performed or/and delayed. In blue color letter, the deliverables corresponding responsible partner is indicated. In the Section 3. there is the comprehensive explanation case by case.

WP1 Coordination and management:

M1.1. Consortium Agreement; **M1.2.** Kick-off meeting; **M1.3.** 1st project meeting; **M1.4.** End-users meeting. **D1.1** Consortium agreement signed; **D1.2** Mid-term report; R: CSIC.

WP2 Data mining and experimental design:

M2.1. Literature search. **D2.1.** Report on microbial populations, fecal contamination indicators, pathogens and EOCs in MAR systems. R: CNR.

WP3 Laboratory testing:

M3.1. Selection of EOCs; **M3.2.** Column experimental setup; **M3.3**. Selection of pathogen indicators; **M3.4.** Microbial community analysis and qPCR assays for specific microbes**. M3.5.** Analysis of the selected EOCs and degradation/transformation products identification.**D3.1.** Kd determination of selected EOCs in batch experiments; **D3.2.** Report on reactive layers efficiency; **D3.3.** Report on pathogens, microbes, EOCs behavior in the batch tests, R: CNRS/CNR**.**

WP4 Pilot MAR:

M4.1. Optimized conditions for FCM-based metabolic and respirometry tests; **M4.2** Toxicity assays in tested layers and sediment tanks.

WP5 Field MAR:

M5.1. Site selected; **M5.2.** MAR permits and design. **D5.1**. Site characterization report; **D5.2.** Project of the industrial prototype to be built; R: AQUALIA.

WP8 Exploitation and dissemination:

M8.1. Communication and exploitation plan. **D8.1** Project website. R: SLU/CSIC.

Methodology & results

Data mining

A literature search was performed to gather the latest knowledge on MAR operations and batch/column experiments. All partners contributed and relevant information was compiled and discussed in D2.1. The responsible partner (IRSA-CNR, Italy) and all partners contributed. Specifically, introduction to suitable MAR types was provided, along with a study case from a target site in Spain. The fate of major microbial and chemical contaminants was reviewed together with processes affecting their transport and fate in MAR. The review has controlled the design of laboratory and pilot experiments to improve the overall performance of the system, with a focus on processes and impacts of microbial and chemical contamination transport and fate.

Laboratory testing

WP3 was carried out by CNRS (France), The first task was to select a number of CECs, with different reported behavior, to represent some of the families frequently detected in the aquatic environment and especially in the WWTP effluents, and obtain their Kd (adsorption constant) onto a number of materials. The list of contaminants to be tested was made by CNRS and CSIC after extensive discussion, and agreed by the rest of the partners. The selected contaminants were (CAS# in parenthesis): Carbamazepine (298-46-4), Ofloxacine (82419-36-1), Diazepam (439-14-5), Venlafaxine (93413-69-5), Atenolol (29122-68-7), Propanolol (525-66-6), Ibuprofen (15687-27-1), Ketoprofen (22071-15-4), Diclofenac (15307-86-5), Acetaminophen (103-90-2), Sulfamethoxazol (723-46-6), Oxazepam (604-75-1), Fenofibric Acid (42017-89-0), Oxybenzone (131-57-7), Benzophenone (119-61-9), Ethylhexylmetoxycinnamate (5466-77-3), and Benzotriazole (95-14-7).

Despite COVID-19 pandemic, the methodology for the batch experiments was established and validated. In late spring and during the summer, more than 200 batch experiments were performed to test the sorption of different materials (sand, clay, woodchips, compost, and zeolite, among others). Different parameters have been tested, such as the contact time between the water and the sediment, the sediment granulometry (crushed vs. natural), the water/soil ratio, and the water composition. We have established that the soil composition is the most important parameter on the sorption efficiency. Some molecules such as Carbamazepine and Atenolol are very well absorbed in compost and woodchips, whereas Ibuprofen disappeared in contact with sawdust (**Figure 1**). Granulometry did not significantly affect the sorption, whereas the water/soil ratio had a slight effect (**Figure 1**). The sorption process was very fast for all contaminants regardless of testing conditions were, and always faster than 30 min. Little differences were observed between experiments performed with Milli-Q water and synthetic wastewater.

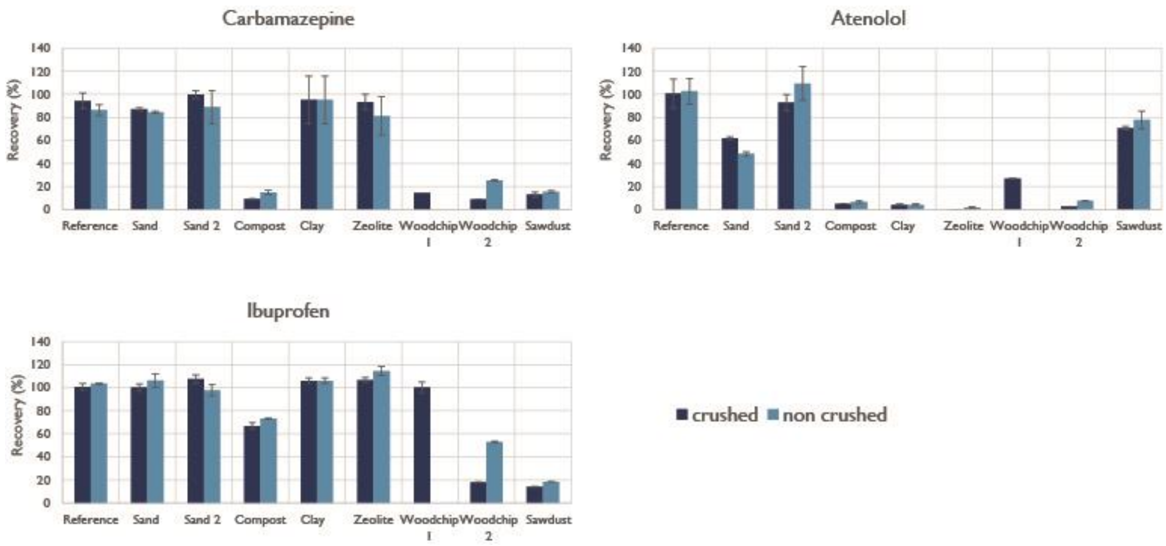

Figure 1: Recovery of Carbamazepine, Atenolol and Ibuprofen in Milli-Q water after 1h of contact with different solid materials. All experiments were performed at a water/solid ratio of 3.

The full results obtained from the batch experiments with Milli-Q water will be provided in the deliverable D3.1. (see Section 3, Table of deliverables). In parallel, a large literature search has been done and the column experimental procedure was decided.
The objectives of the two other tasks were to design and develop the column setup. At present, the construction of the columns is almost finished.

Pilot MAR testing
The pilot field tasks started with the 6th recharge process (6RP) from May through August 2019, continuously infiltrating 0.4 m/d. A test was conducted in June at T2 and T4 systems, injecting BP3, a UV filter, into the recharge water. Simultaneously, a general sampling event at the entire pilot system was performed. After 6RP, an operational stop followed to dismantle hoses and pipes, and to remove the accumulated deposits. Some system improvements were implemented:

- Grass was planted in T2, T4, T5 and T6 basin surfaces with the goal of testing their influence in the fate of chemical and biological contaminants (**Figure 2**).
- Volumetric humidity probes at every reactive barrier and the aquifers, from surface up to 60 cm deep, with a measurement every 10 cm to determine the wetting front (**Figure 2**).
- Dissolved oxygen probes were installed into T2, T3 and T4 barriers, at 5, 10, 15, and 20cm deep, with to control the oxygen behaviour during recharge events (**Figure 3**).
- Flowmeters were placed at the basins' outlets, but they did not properly work in this system design and were finally removed during the 7RP.

Figure 2: General view of recharge basins and aquifers (6). T1 and T3 are the NO plants representative basins. Oxygen probes are installed at T2, T3 and T4 systems at 5, 10, 15 and 20 cm from surface. Humidity sensors are placed in the middle of the basin surface and in the T5 aquifer close to B piezometer section.

The 7RP went on from 2020, 11th January until 9th July 2020, operating at 0.4 m/d. The outlet head was 1.4 m decreasing to 1.2 m due to problems with flowmeters. On March 26th these were definitely removed and discharge has been controlled since then by periodic volumetric estimates. Two sampling campaigns were done, from WWTP inlet up to the MAR systems discharge.

Recharge was stopped between 9th and 20th July 2020 to prepare the system for doubling the recharge rate and testing two recharge schemes: continuous and pulse (2 hours) water flow input. Both events infiltrated the same flow rate. From July 21st to August 3th, a general sampling campaign was performed including, this time *E.coli* and N species to the chemical analysis. This 8RP recharge experiment finished on August, 7. Relying on the results obtained, the pulse approach was adopted for the next recharge event, 9RP, at all 6 systems which started on September 29, with a 0.8 m/d flowrate. This recharge period is still operating.

Figure 3 and **Figure 4** display monitoring records during the 8RP operated under continuous and pulse recharge approaches. 8RP was carried out after a very short dry (stop) period, which explains why the water content was unusually high. T1 basin developed almost immediately a water layer, due precisely to this short dry period, thereby saturating the reactive barrier. A delay after the stop of recharge is observed in the T1 curves from **Figure 3**. This effect appeared to be also reproduced in the T4, but it could not really be identified by the end of the recharge period because the probe ran out of batteries. The pulse effect on moisture was clearly identified, by small rises and falls in water contents, while continuous recharge kept constant. Pulsed recharge (cycles) affected both dissolved oxygen and temperature. Air temperature has a wide range of variation during the day; this effect is reflected in the T3 records from **Figure 4.** Cycles allow oxygen to access the aquifer between recharge pulses, which can be also observed in **Figure 4**. The lack of plants can also have an effect, favouring the entry of air between pulses.
These observations will be analysed in connection with the analytical results from the sampling campaigns samples that were taken and properly preserved, until analysis. In the case of microbiological analysis to be performed by IRSA-CNR, some samples have already been analysed, but the data are still being treated. In the case of chemical analyses, CECs, anions, cations, N isotopes and DOC, tasks associated to CSIC, several samples have already been analysed, but considering that around 60 CECS and metabolites are investigated in pilot studies, the volume of data acquisition and treatment is so huge that a long period of time is required to finally obtain the

results. To date, the complete data set analysed corresponds to the recharge event with BP3 spiked wastewater. All other chemical analyses are on-going, but delayed

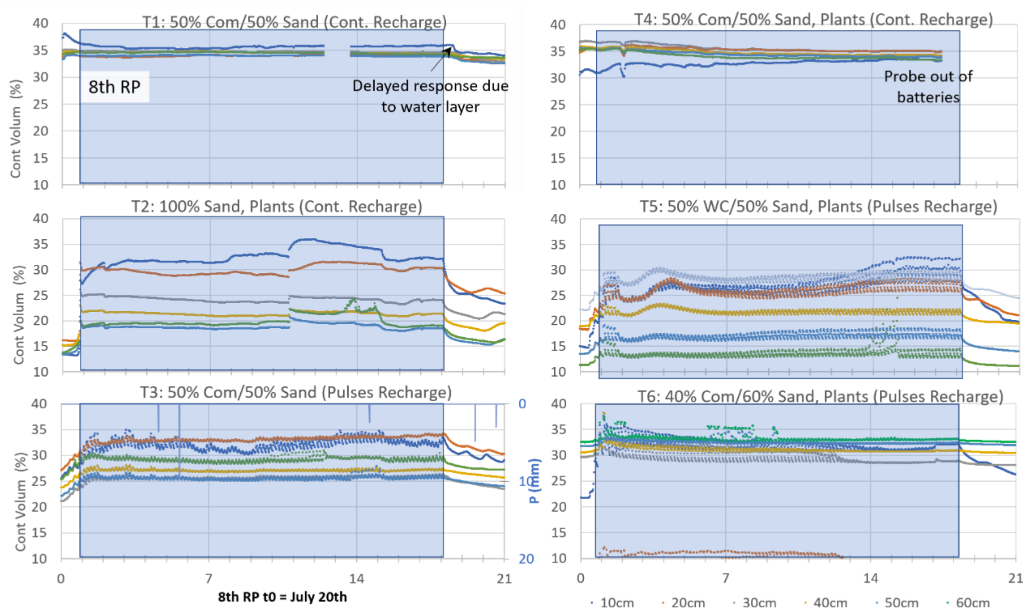

Figure 3: Volumetric water content measured at the centre of every recharge basin, from 10 to 60 cm depth, during the 8RP.

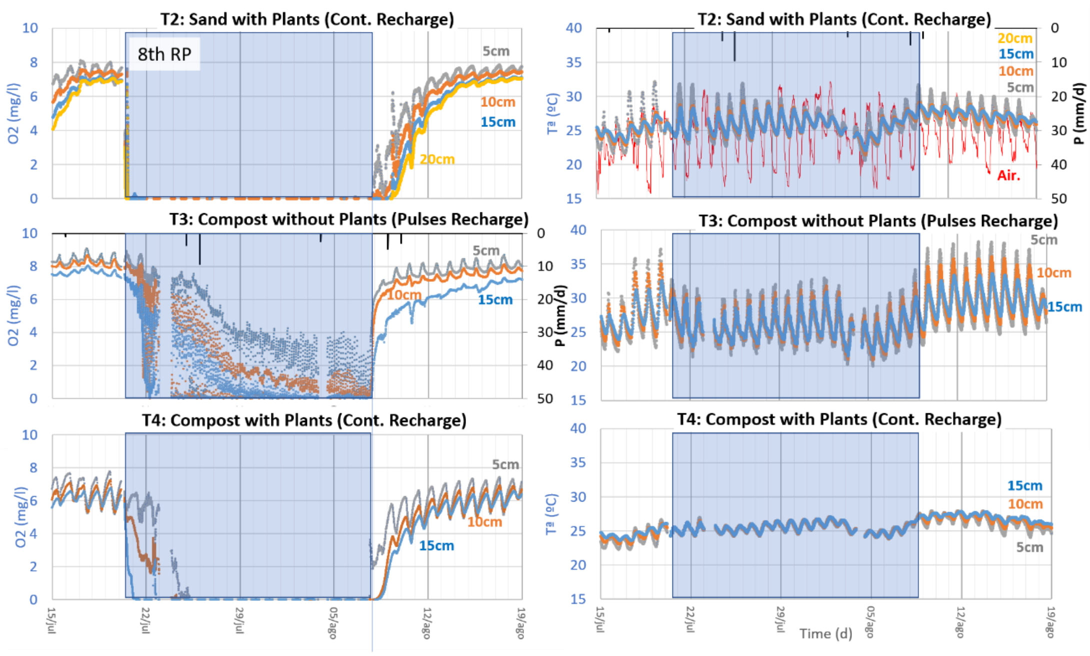

Figure 4: Dissolved oxygen measured into T2, T3 and T4 recharge basin, at 5, 10, 15 and 20 cm deep, registered during the 8RP. Left column represents dissolved oxygen values, while right column displays temperatures at the same points.

Functional analysis was carried out by SLU on water and reactive barrier material from the Palamos pilot MAR from the July 2018 and December 2018-January 2019 campaigns. 31 water samples and 52 barrier samples have been processed in the laboratory. All data needed for the analyses of the functionality of the systems is collected: water chemistry, nitrogen removal and abundances of key players involved in transforming inorganic nitrogen compounds. Analyses of the overall microbial community composition are ongoing. Preliminary results, based on the relative abundances of functional groups responsible for transformation of nitrogen compounds, showed that the assemblages differ between the reactive barrier material itself and the water passing through (**Figure 5 A**). The reactive barrier material, as indicated by tank number, did not affect the assemblage of functional groups (**Figure 5B**). Looking at the water samples only, the passage through the sand filter in the tank did not change the nitrogen cycling assemblages (**Figure 5 C**). The depth of the reactive layer on the other hand, had an effect, with barrier samples from deeper layers clustering together (**Figure 5 D**). The analyses of sequence data for the overall microbial community will provide a deeper insight into which specific bacterial and archaeal taxa are present in the systems and analyzing the data together with performance data will give more information.

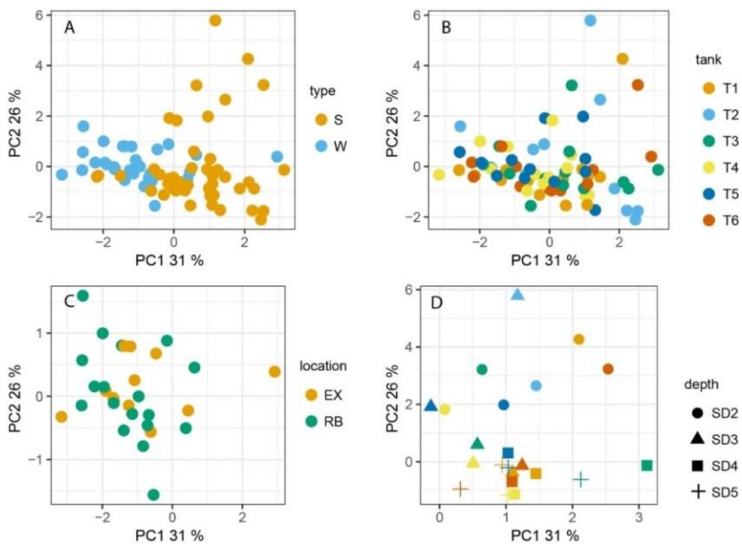

Figure 5: Principal components analysis based on ratios between functional and total community sizes for the nitrogen transforming processes nitrification, denitrification, nitrous oxide reduction, and DNRA in water and barrier samples from the Palamos pilot MAR system. (A) All samples, sample type indicated (S=solid; W=water). (B) All samples with tank numbers representing barrier types: T1 = compost/no plants/sand; T2 = sand/plants/sand; T3 = compost/plants/sand + gravel; T4 = compost/plants/sand; T5 = woodchips/plants/sand; T6 = compost/ plants/sand + gravel. (C) Water samples, sampling location: EX = water outlet after sand filter; RB = water sampled just under reactive barrier. (D) Barrier material samples at end of experiment, tank number (see legend for panel B) and sampling depth indicated: SD2 = sand on top of barrier; SD3 = 27 cm; SD4 = 37 cm; SD5 = 47 cm.

SLU has also developed a method for DNA extraction from woodchips, by combining and modifying existing commercial kits. For downstream applications after DNA extraction, it is necessary that the extraction method used is adjusted to the matrix from which DNA is extracted. Wood derived material is a good option as component in a reactive barrier, but it can be very difficult to work with, hence the need for method development.

Field MAR Testing

Aqualia (industrial partner) looked best location for the real field scale MAR prototype installation, despite the COVID-19 pandemic. Nonetheless, the decision has been made to implement the MAR process at the Lleida WWTP operated by Aqualia. The geotechnical study was carried out in June 2020 (after the COVID-19 lockdown). The soil displayed potentially damaging anthropic fillings (**Figure 6**). Since then information has been received on how to modify the terrain in order to adapt it. CSIC and Aqualia at this time are evaluating the economic impact of such modifications, and thus the feasibility of the implementation in that location.

Figure 6: Image of the area selected for the implementation of the MAR prototype (left) and detail of the stratus found (right) shown a very high heterogeneity.

Development and application of modeling tools

Regarding the modeling tools, partner UPC started to produce the basis of the numerical models by constructing and verifying the conceptual model using data available prior to MARadentro. Specifically, we have constructed a model evaluating the impact of the compost material added in the reactive barrier on the carbon and nitrogen cycle (Canelles et al. 2020, the full citation can be found in Section 7), all redox processes in a MAR facility (Rodríguez-Escales et al. 2020), and the model basis to assess the role of biomass as a sorbent of organic pollutants, specially, those with high $logD_{ow}$ (Rodríguez-Escales et al. 2020).

Redox potential (*Eh*) was measured for a year and every 15 min in an infiltration pond. The use of single-point redox sensor probes and the construction of a complex bio-geo-chemical model incorporating heat transport and photosynthetic growth of microorganisms allowed reproducing quite well the redox dynamics in the first meter depth of an infiltration pond (**Figure 7**).

On the other hand, we have also advanced on the understanding of the processes driving the fate of emerging organic compounds. In particular, we performed a mechanistic model of sorption of a set of UV-filters demonstrating, for the first time in the literature, that biofilm could play an important role in the sorption of these compounds in the porous media. The particular case of BP3 is represented in **Figure 8**.

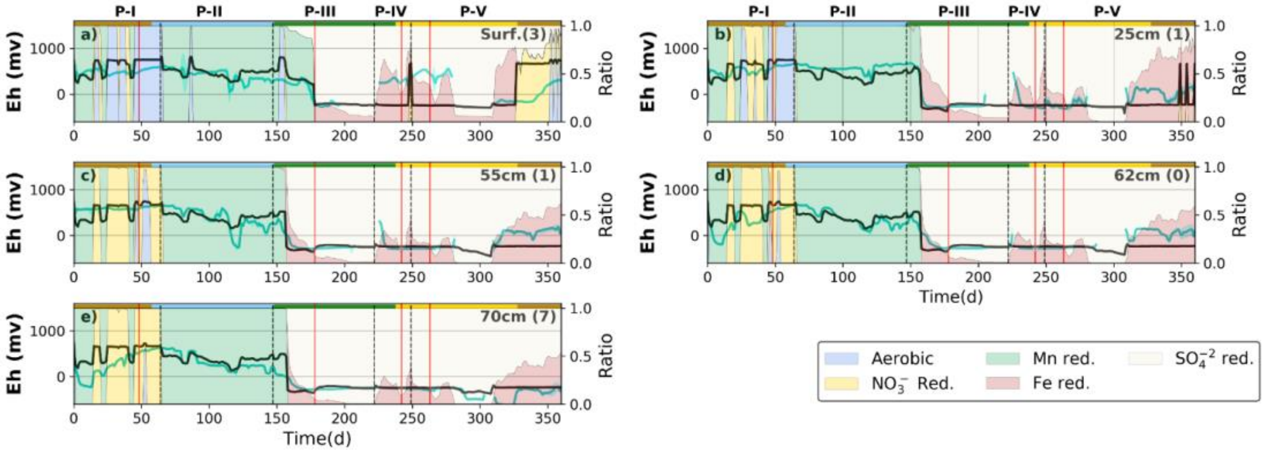

Figure 7: Modeling reproduction of potential redox in an infiltration pond (Rodríguez-Escales et al. 2020)

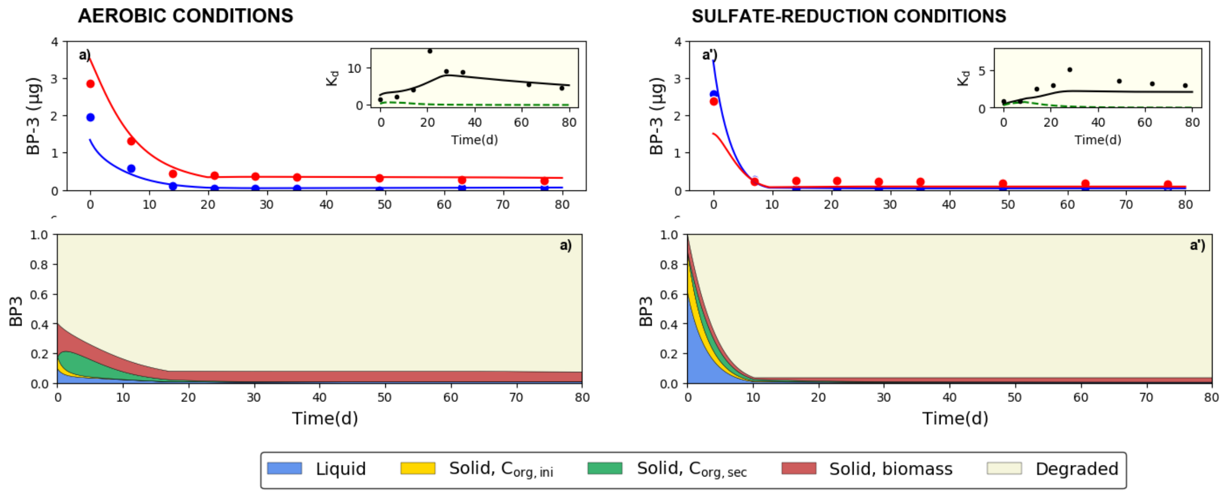

Figure 8: Modeled fate of BP3 at different redox conditions in a batch experiment (Rodríguez-Escales et al. 2020).

In short, we go ahead the deadlines because we have not relied on the production of experimental data, but on the construction of the conceptual models regarding the main processes occurring in MAR applications. We anticipate that the delayed produced by the COVID19-pandemia on experimental work, certainly will impact the further modelling efforts.

Progress on multi-disciplinary work

In the starting point of the project, all partners performed an extensive data mining to produce D2.1. Later on, and based on this acquired knowledge, discussion and final agreement about the materials to be tested as reactive barriers components, as well as the selection of CECs and indicator microorganisms to be monitored was made by all partners based on their respective expertise. In lab column experiments also contributions from the experts in hydrology, chemistry, microbiology and engineering were needed to design the best experiment set up to obtain the required data to understand the system as a whole and replicate it at higher scale by considering the role of the key factors driving the dynamics of CECs degradation and pathogens inactivation. A multi-disciplinary approach also occurred in the field because sampling is assumed by the partners from different and complementary points of view and understanding of systems behaviour, promoting discussion and identifying future research ideas to be tested.

b. Collaboration, coordination and mobility

Most MARadentro partners have successfully collaborated for years, and thus, it can be regarded as an extension of previous collaborations and as the consolidation of established connections among partners. Some laboratory and field tasks were designed to be carried out by students from every partner, thus ensuring a continuous interaction among partners, which has been realized in the sampling campaign during the long-period recharge event in spring-summer 2019. Some exchanges of researchers among the partners, mostly to perform laboratory experiments were foreseen. So far only one student is performing a Postdoc stay. Senior researchers and PhD students had not the chance to carry out research stays as a consequence of the COVID-19 pandemic. Mobility has been clearly affected. Nevertheless, online meetings have been organized in order to plan and manage the water chemistry data and the protocol for column experiments.

The project has a clear transnational nature, as originally configured. Initial MAR studies at a laboratory scale are performed in France by CNRS. The pilot MAR system (managed by CSIC and UPC) and the real-scale MAR (managed by the industrial partner, Aqualia) are located in Spain, where chemical analysis is also performed. Microbial communities' studies (SLU), as well as microbiological analysis (IRSA-CNR), are carried out in Sweden and Italy, respectively.

In particular, a close collaboration is being carried out since February 2020 between CNRS at Montpellier and CSIC. The Ph.D. Cristina Valhondo, from CSIC is doing a PostDoc at the CNRS to participate in the column laboratory studies focused to identify the best performance reactive barrier materials composition to degrade the selected organic chemical pollutants.

A close collaboration was established among all the partners to help CNR in the writing of Deliverable 2.1, of which it was the responsible. Particular collaborations were developed between Aqualia and CSIC, in order to design and implement the real field demo site on the basis of the knowledge acquired from the pilot MAR at Palamós. In addition, Aqualia has actively collaborated with SLU in the creation of the collaborative space through Office 365 https://fcces.sharepoint.com/sites/MARadentro, besides the project website.

CNRS partner as well as CSIC, are part of another JPI project funded in the 2018 joint call named UrbanWat. We jointly developed the methodology for batch experiments at Montpellier (France).

MARadentro is connected with the Spanish project ROUSSEAU (http://rousseauproject.es). Both projects are coordinated by Dr. Diaz-Cruz and thus, a smooth collaboration was established from the beginning of MARadentro. The ROUSSEAU project aims to fill in current knowledge gaps in the reuse of regenerated water in agricultural irrigation (wastewater reuse after further treatment). To this end, the propagation of waterborne biological and chemical emerging contaminants to soil, plants, and ultimately humans are investigated in different types of crops, water reclamation techniques, irrigation systems, and study sites. The regenerated water produced by the WWTP secondary effluent infiltration through reactive barriers in MARadentro is used to irrigate vegetables grown in two agricultural plots located by the MAR pilot in Palamós. Results to date evidence that MAR water significantly decreases the transfer of chemical and biological contaminants to vegetables in comparison with the WWTP outflow.

Collaboration also occurs with Catalonian project RESTORA (https://restora.h2ogeo.upc.edu/), whose coordinator is also the deputy-coordinator of MARadentro, Prof. Carrera. This project focuses on the use of organic substrates to accelerate water renaturalization in MAR. In this case, emphasis is placed on Antibiotic resistance genes and chaotic mixing.

c. Impact and knowledge output

So far, we have studied water quality improvement processes at laboratory and at pilot MAR scales, which has allowed us to select the most appropriate materials for reactive barriers testing and the microbial communities involved in the contaminants degradation are being identified. Modeling tasks related to the development of tools to predict behavior and environmental risk, have progressed at a good pace, which will allow us to quantify the processes that take place and estimate what the expected impact will be on scenarios different from thos tested. All this work contributes to the expected impact to make MAR a safe and accepted technology for water management adapted to the emerging water challenges. In particular, by implementing reactive layers we will demonstrated that MAR is a sound and safe technology, capable to increase fresh water resources as well as to improve ecological status and chemical quality of GW, while ensuring no negative impacts over human health.

After MAR is implemented at real field scale, an economic analysis of the implementation and operational costs will facilitate the market replication of MAR into the water sector. Key scientific recommendations, validated by the demonstrable data produced, will be formulated and legislative refinement suggested over the basis of scientists and stakeholder's guidance. So far, we are in progress identifying and understanding the system at the two lower scales, lab and pilot. Summarizing, we are successfully progressing towards the design of a MAR prototype, implemented with reactive barriers (rbMAR) close to market.

The results are expected to impact on the industrial sector (WWTPs operator companies, materials development companies, forest resource management, compost producers, and water management entities, among others), the legislative bodies (directives and guidance for water reuse in MAR, groundwater protection, wastewaters, water framework directive amendments, river basin management plans, among other), and the society by gaining its acceptance based on the scientific results obtained.

The MARadentro tangible outputs produced in the reporting period are:

- Publications: 4 published and 3, in preparation, submitted and under review.
- Popular conferences and mass media: 4 activities
- Contributions in Conferences: 4 oral + 3 posters.
- Organization of an End-users meetings
- Lectures on MAR in, two Official University Master programs (UPC and UB).
- 3 Master Theses + 5 PhD Thesis on-going.
- Models and other software tools developed.

Some of the above listed items constitute, indeed, exploitable results. Intellectual property protection has not been considered yet.

3. Table of Deliverables

Deliverable name	Lead partner (country)	Date of delivery (dd/mm/yyyy)	Changes, difficulties encountered and new solutions adopted
WP1			
D1.1. Consortium agreement signed	CSIC (Spain)	17/06/2019	According to plan
D1.2. Mid-term report	CSIC (Spain)	31/10/2020	According to plan (the present document)
WP2			
D.2.1. Report on Microbial Population, Faecal Contamination Indicators, and CECs in MAR Systems	IRSA-CNR (Italy)	08/05/2020	The deliverable aimed to review the state of the art of recent literature on the topic. The current background knowledge is mainly based on risks associated to chemical pollution. Reports on microbial contamination levels are scattered, but we attempted to link and review major chemical and microbial process to improve the overall understanding on the fate and removal of organic contaminants in MAR systems. The deliverable was delayed due to the unexpected but necessary rearrangement of the research team, now leaded by a different PI. Dr. Stefano Amalfitano has replaced Dr. Caterina Levantesi who resigned for personal reasons partly linked and aggravated by the current pandemic.
WP3			

Deliverable name	Lead partner (country)	Date of delivery (dd/mm/yyyy)	Changes, difficulties encountered and new solutions adopted
D.3.1. Kd measurements in batch experiments for the target PPCPs	CNRS (France)	01/12/2019	Delay in contracting the post doc dedicated to laboratory experiments. The post-doc finally started in February 15th, 2020, however, less than 1 month later the COVID-19 pandemic started and delayed all the laboratory experiments. Nevertheless, during the lockdown, we developed the methodology and started the experiments as soon as it was possible. The deliverable will be delivered in December 2020.
D.3.2. Evaluation of the reactive layers efficiency for different flow conditions	CNRS (France)	Delayed (from 03/2020)	The delay in contracting the post-doc also impacted this deliverable as well as the COVID-19 pandemic. The column design is almost validated. The foresee date of delivery is 09/2021.
D3.3. Report on pathogens, microbes, EOCs behavior in the batch tests,	CNRS (France) and IRSA-CNR (Italy)	Delayed (from August 2020)	The delay is consequence of the delay in having optimized the set-up for the column experiments; delay of previous D.3.1. and D.3.2
WP 5			
D5.1. Site characterization report	Aqualia	15/09/2020 (from 06/2019)	Delayed first by technical issues at the company, and further by the lockdown period and related issues derived from COVID-19.
D5.2. Project of the industrial prototype to be built	Aqualia	Delayed (from 05/2020)	It is still in process, because of the high heterogeneity identified in the prospection of the soil in the finally selected WWTP. We foresee to deliver it by the end of 2020.
WP8			
D.8. MARadentro Website www.maradentro-jpi.eu	SLU (Sweden)	25/11/2019	Launch of project website, according to plan.

4. Budget review

Please include a budget breakdown here, i.e. how the funding has been used so far.

<u>Personnel</u>: 2 Ph.D. students hired at CSIC, 1 postdoc student hired at CNRS.

<u>Equipment</u>: 2 freezers (at Palamós and CSIC, to preserve samples). A multisensor device for installation at the pilot MAR in Palamós).

<u>Travel and subsistence</u>: Field recharge and sampling campaigns. Scientific Meetings and Kick-off project meeting (previous COVID-19). WPs-meeting at CNRS (Montpellier, France).

<u>Consumables</u>: related to MAR pilot field tasks (maintenance, sampling material) and chemical and microbiological analysis (LC-columns, standards, vials, reactive, organic solvents, …). Material for laboratory column tests.

<u>Subcontracting:</u> some analytical services (CNRS)

<u>Other costs</u>: Meetings registration (face-to face and virtual meetings)

Aqualia requested CDTI (Spain) to modify the approved budget by adjusting the dedication and the real cost of the personnel working on the project, this does not imply a modification in the total amount financed or in the subsidy to be received.

Partner IRSA-CNR did not yet received active funds from the Italian Ministry of University and Research. However, the research team members were devoted in collecting all suitable information for the baseline consolidation of current knowledge to promote the application of advanced tools for the microbial and chemical characterization of MAR systems. Analytical activities were also carried out in collaboration with Partners 1 (CSIC) and 2 (UPC) to assess the total coliforms and pathogen load within the targeted pilot plant in the Palamos pilot MAR site (Spain).

5. Consortium Meetings

N°	Date	Location	Attending partners	Purpose/ main issues/main decisions?
1	24th May 2019	Madrid (Spain)	CSIC, UPC, Aqualia, IRSA-CNR, CNRS, SLU	Kick-off meting
2	5 December 2019	Montpellier (France)	CNRS, CSIC, IRSA-CNR	WPs meeting to design column experiments
3	4-6	Barcelona	CSIC, UPC,	Project meeting

	December 2019	(Spain)	Aqualia, IRSA-CNR, CNRS, SLU	and End-users meeting
4	11 June 2020	Lund (Sweden) – Suspended and replaced by a virtual meeting	CSIC, UPC, Aqualia, IRSA-CNR, CNRS, SLU	Project meeting Assessment of the project development
5	8 October 2020	Virtual meeting	CSIC, UPC, Aqualia, IRSA-CNR, CNRS, SLU	Project meeting Assessment of the project development and preparation of the Mid-Term Progress Report

6. Stakeholder/Industry Engagement *(Maximum 1 page)*

Thanks to the visibility of MARadentro achieved through the End-users meeting (Barcelona, Dec 2019), we have established cooperation with several water agencies and actors in the field, and so far we have achieved:

- The Catalan Water Agency (ACA) funded the project RESTORA - *Managed recharge of aquifers and use of Organic Substrates to Accelerate water renaturalization* (Ref. ACA210/18/00040), installed at the same site and in connection with the MAR pilot system. CSIC and UPC are involved.
- Formal documented agreement with Consorcio Costa Brava (CCB) supporting the execution of MARadentro within the Palamós WWTP.
- Involvement as the Coordinator of COMAIGUA S.L, a management of integrated water cycle company, in the project proposal *LIFE-REMAR: Reactive barriers for water renaturalization during managed aquifer recharge in the Baix Camp region (Spain)*) in close connection with MARadentro. The company Mejoras Energéticas S.A. is also involved as an industrial partner. The proposal was submitted in July 2020.
- A Research Technical Support contract signed between CSIC and Consorci Besós-Tordera (CBT) a management of integrated water cycle company.

7. List of Publications produced by the Project - Open Access

Metadata on all project publications are required to be submitted as part of the final reporting. This will be done via the **Open Data & Open Access platform**, available at: http://opendata.waterjpi.eu/ (also accessible from the bar menu of the Water JPI website).

International	Peer-reviewed journals	1. Cristina Valhondo, Lurdes Martínez-Landa, Jesús Carrera, M. Silvia Díaz-Cruz, Stefano Amalfitano, Caterina Levantesi. Six Artificial Recharge Pilot Replicates to gain Insight into Water Quality Enhancement Processes. Chemosphere 240 (2020). DOI: 10.1016/j.chemosphere.2019.124826. 2. Cristina Valhondo, Jesús Carrera, Lurdes Martínez-Landa, Jingjing Wang, Stefano Amalfitano, Caterina Levantesi, M. Silvia Díaz-Cruz. Water 12 (2020). DOI: 10.3390/w12041012. 3. Adrià Sunyer, Bárbara Benedetti, Cristina Valhondo, Lurdes Martínez-Landa, Jesús Carrera, Marina Di Carro, Emanuele Magi, M. Silvia Díaz-Cruz. Use of integrative samplers in the removal estimation of pharmaceuticals and personal care products in a WWTP with a reactive barrier MAR system as tertiary treatment. *In preparation.* *4.* Jingjing Wang, Jesús Carrera, Maarten W. Saaltink, Cristina Valhondo. A general and efficient numerical solution of reactive transport with multirate mass transfer. Computers and Geosciences. *In review*. 5. Canelles, A., Rodríguez-Escales, P., Modrzynski, J., Albers, C. and Sanchez-Vila, X. 2020. Impact of compost reactive layre on hydraulic transport and C&N cycles: biogeochemical modelling of infiltration column experiment. *Submitted to Science of the Total Environment.* 6. Rodríguez-Escales, P., Barba, C., Sanchez-Vila, X., Jacques, D. and Folch, A. 2020. Coupling flow, heat and reactive transport modelling to reproduce in-situ redox potential evolution: application to an infiltration pond. *Environmental Science and Technology. Doi.org/10.1021/acs.est.0c03056.* *7.* Rodríguez-Escales, P. and Sanchez-Vila, X. 2020. Modeling the fate of UV filters in subsurface: Co-metabolic degradation and the role of biomass in sorption processes. *Water Research 168, 115192.*
	Books or chapters in books	-
	Communications (presentations, posters)	1. Cristina Valhondo, Lurdes Martínez-Landa, Jesús Carrera and M. Silvia Díaz-Cruz. Does the use of organic substrates favour the degradation of emerging organic contaminants during artificial recharge of aquifers? Platform. SETAC 2019. Helsinky (Finland). May 2019. 2. Cristina Valhondo, Lurdes Martínez-Landa, Jesús Carrera, Silvia Díaz-Cruz, Stefano Amalfitano, Caterina Levantesi.

		Quality restoration of Impaired wáter through artificial recharge. Platform. Goldschmidt 2019. Barcelona, August 2029. 3. Raul Carrey, Cristina Valhondo, Lurdes Martínez-Landa, Albert Soler, Neus Otero. Artificial recharge using wastewater treatment plant effluents: Evaluation of nitrogen fate in meso-scale experiments by means of an isotopic approach. Platform. Goldschmidt 2019. Barcelona, August 2019. 4. Jesus Carrera, Cristina Valhondo, Lurdes Martínez-Landa, Jingjing Wang, Maarten W. Saaltink, Silvia Díaz-Cruz. Water Quality Challenges in MAnaged Aquifer Recharge. Platform. Goldschmidt 2019. Barcelona, August 2019. 5. Jingjing Wang, Jesús Carrera, Maarten W. Saaltink, Cristina Valhondo. Reactive Transport Modeling of microbial-mediated degradation in MAR. Poster. Goldschmidt 2019. Barcelona, August 2019. 6. Lurdes Martínez-Landa, Cristina Valhondo, Jesús Carrera. Hydrogeological characterization of a meso-scale artificial recharge experiment focused on emerging contaminants fate. Poster. Goldschmidt 2019. Barcelona, August 2019. 7. Cristina Valhondo, Jesus Carrera, Lurdes Martínez-Landa, Stefano Amalfitano, Caterina Levantesi, Silvia Diaz-Cruz. Managed aquifer recharge with reactive barriers (rbMAR): achivements and future challenges. Poster. SETAC 2020. Virtual meeting. May 2020.
National (separate lists for each nationality)	Peer-reviewed journals	-
	Books or chapters in books	-
	Communications (presentations, posters)	-
Dissemination initiatives	Popular articles	-
	Popular conferences	1. Science Week organized by the Barcelona City Council. October 26, 2019. Silvia Díaz-Cruz. Round Table https://www.barcelona.cat/barcelonaciencia/ca/activitat/els-elements-quimics-i-el-seu-rol-en-larea-de-la-salut-i-laigua?edicionode=3402 http://www.taulaperiodica.cat/activitat/els-elements-quimics-i-el-seu-rol-en-larea-de-la-salut-i-laigua/
	Others	1. Science Week organized by the Escola Thau Barcelona. Invited conference: Química i Medi Ambient. February 6, 2019. Silvia Díaz-Cruz. 2. Tertulia in the radio magazine EL FAR of the Radio Communication Network hosted by Josep Mª Cano. 45 min. "Fàrmacs al medi aquàtic". June 13, 2019.

		http://www.radiolescala.cat/audio/22658-el-far-ii-13-06-19

8. Knowledge output transfer

For each of the Knowledge Output arising from the project so far, please complete the following table.

Short Title *Please provide a short and concise title to describe the Knowledge Output*	
Knowledge Output Description *Please only include generated Knowledge Outputs, not those that are expected. Note: Knowledge Outputs can be non-deliverables, milestones or 'grey knowledge'. Also, multiple Knowledge Outputs could exist within one deliverable, and should be separated.* *Try to give a comprehensive description, making the Knowledge Output fully understandable to a non-expert.* *If relevant please provide detail of where the Knowledge Output differs from its equivalent, e.g. What are the key characteristics of the Knowledge Output? What research is it adding to and what is innovative about the Knowledge Output? (Max 500 characters).*	
Knowledge Type	Please choose one option – delete the rest: * exploitable scientific result * scientific publication * report * book/review * RTD protocol/technical manual * guidelines/standards * training activity/learning module * software/modelling tools * product * prototype * services/tools * multimedia * data * other
Link to Knowledge Output *If you can provide a link to the Knowledge Output*	

then please do so, e.g. digital object identifier (DOI), web address, download, research paper. *If the Knowledge Output is not publicly available currently but will be in the future, please provide details. Also, if it is available but only upon request, please state this.* *If the Knowledge Output is not planned to be publicly available, please state "Not available for public".*	
Sectors & Subsectors *Choose as many options as required from the list. Pick those sectors that you think would benefit from the application of this Knowledge Output.*	• Basin Management • Flood Risk Management • Water Scarcity and Droughts • Drinking Water • Bathing Water • Emissions and Water Reuse • Adaptation to Global Change • Others o Other General o Agriculture o Governance o Consumer Health & Welfare o Finance o Modelling & Prediction o Socio-Economics o Stakeholder Involvement
End User *Choose as many options as required* *Per identified End User, please identify possible applications of the Knowledge Output.*	o Education & Training o Environmental Managers & Monitoring o Industry o Policy Makers / Decision Makers o Scientific Community o Civil Society o Other
IPR *Please indicate whether IPR has been applied to this Knowledge Output (applied for a patent, copyright etc), or not.* *Please insert "n/a" if no IPR has been applied.*	
Policy-Relevance If the Knowledge Output is relevant to the WFD or any other related Directives, please list and explain why	

Status *Please identify whether the Knowledge Output is finalised, is still being generated or whose status/future is unknown. Consider:* *• Is your knowledge conclusive enough that it provides sufficient evidence to make an impact on, or be applied by, an End User?* *• Is there a corroborating body of evidence, or are contradictory results, available?* *• Does your knowledge progress beyond the current state-of-the-art / evidence base?* *• Is more research or demonstration needed to validate the results?*	

Knowledge Output 1

Short Title	Master Thesis Behaviour of emerging pollutants of urban origin during the artificial recharge of aquifers and their transfer through the use of reclaimed water in agriculture.
Knowledge Output Description	Student: Estefanía Fernández Moreno Mentor: M. Silvia Díaz-Cruz and Cristina Valhondo Date: 26 October 2019 Institution: CSIC – UPC Overall, the concentrations of the CECs decreased during artificial recharge thanks to the reactive barriers. The artificial recharge systems are especially effective in the fluoroquinolone, antidepressants and β-blockers removal, >99%. There was effective CECs transfer from water to crops, but much lower when using recharged water.
Knowledge Type	* exploitable scientific result
Link to Knowledge Output	http://hdl.handle.net/2117/179815
Sectors & Subsectors	• Water Scarcity and Droughts • Drinking Water • Emissions and Water Reuse • Adaptation to Global Change

	• Others o Agriculture o Governance o Socio-Economics o Stakeholder Involvement
End User *Choose as many options as required* *Per identified End User, please identify possible applications of the Knowledge Output.*	o Education & Training o Environmental Managers & Monitoring o Industry o Policy Makers / Decision Makers o Scientific Community o Civil Society
IPR	nla
Policy-Relevance If the Knowledge Output is relevant to the WFD or any other related Directives, please list and explain why	The contributions will favour the development, implementation, and enforcement of EU environmental and climate policy and legislation boosting the integration of environmental and climate objectives into other EU policies, such as the **new Regulation 2020/741 on water reuse** and to **reach zero environmental contamination** stated in the **European Green Deal**. The findings can be integrated into or modify current EU directives, namely the **Water Framework Directive 2000/60 and the daughter groundwater Directive 2006/118.** Considering that the use of regenerated water in agriculture must be in accordance with Annex I of the new Regulation 2020/741, the wastewater used as source water must fulfil the **wastewater Directive 91/271/CEE.** However, if the system provides outstanding performance in removing CECs, the **Directive 91/271/CEE could be amended considering the proposed water regeneration approach**
Status *Please identify whether the Knowledge Output is finalised, is still being generated or whose status/future is unknown. Consider:* *• Is your knowledge conclusive enough that it provides sufficient evidence to make an impact on, or be applied by, an End User?* *• Is there a corroborating body of evidence, or are contradictory results, available?*	Finalized

• Does your knowledge progress beyond the current state-of-the-art / evidence base? *• Is more research or demonstration needed to validate the results?*	

Knowledge Output 2

Short Title	Master Thesis Study of the degradation of l'Oxybenzone in the recharge managed by the aquifers with reactive barrier mitigation HPLC-MS/MS and electrochemical techniques
Knowledge Output Description *Please only include generated Knowledge Outputs, not those that are expected. Note: Knowledge Outputs can be non-deliverables, milestones or 'grey knowledge'. Also, multiple Knowledge Outputs could exist within one deliverable, and should be separated.* *Try to give a comprehensive description, making the Knowledge Output fully understandable to a non-expert.* *If relevant please provide detail of where the Knowledge Output differs from its equivalent, e.g. What are the key characteristics of the Knowledge Output? What research is it adding to and what is innovative about the Knowledge Output? (Max 500 characters).*	Student: Naíma Mohamed Rodríguez Mentor: M. Silvia Díaz-Cruz Date: 21 Julio 2020 Institution: CSIC – UB There is little information on BP3 derivatives and thus it is difficult to draw clear conclusions about the nature and toxicity of these compounds. HPLC-MS is sensitive enough to determine BP3 and metabolites at trace levels, as found in the environment, however, electrochemical techniques are not that sensitive and thus they are useful in the screening of samples for further HPLC-MS analysis.
Knowledge Type	* Review-scientific paper
Link to Knowledge Output	http://www.ub.edu/dqaelc/masters.html
Sectors & Subsectors *Pick those sectors that you think would benefit from the application of this Knowledge Output.*	• Drinking Water • Emissions and Water Reuse • Adaptation to Global Change
End User *Per identified End User, please identify possible applications of the Knowledge Output.*	o Education & Training o Environmental Managers & Monitoring o Industry o Policy Makers / Decision Makers o Scientific Community o Civil Society
IPR	nla
Policy-Relevance If the Knowledge Output is relevant to the	The contributions will favour the development, implementation, and enforcement of EU

WFD or any other related Directives, please list and explain why	environmental and climate policy and legislation boosting the integration of environmental and climate objectives into other EU policies, such as the **new Regulation 2020/741 on water reuse** and to **reach zero environmental contamination** stated in the **European Green Deal**. The findings can be integrated into or modify current EU directives, namely the **Water Framework Directive 2000/60 and the daughter groundwater Directive 2006/118.** Considering that the use of regenerated water in agriculture must be in accordance with Annex I of the new Regulation 2020/741, the wastewater used as source water must fulfil the **wastewater Directive 91/271/CEE.** However, if the system provides outstanding performance in removing CECs, the **Directive 91/271/CEE could be amended considering the proposed water regeneration approach**
Status *Please identify whether the Knowledge Output is finalised, is still being generated or whose status/future is unknown. Consider:* *• Is your knowledge conclusive enough that it provides sufficient evidence to make an impact on, or be applied by, an End User?* *• Is there a corroborating body of evidence, or are contradictory results, available?* *• Does your knowledge progress beyond the current state-of-the-art / evidence base?* *• Is more research or demonstration needed to validate the results?*	Finalized

Knowledge Output 3

Short Title	Master Thesis Title: Evaluation of the Artificial Recharge of Aquifers as Tertiary Treatment in Wastewater Treatment and Comparison with other Tertiary Treatments.
Knowledge Output Description *Please only include generated Knowledge Outputs, not those that are expected. Note: Knowledge*	Student: Ineyser Morillo Santana Mentor: M. Silvia Díaz-Cruz and Cristina Valhondo

Outputs can be non-deliverables, milestones or 'grey knowledge'. Also, multiple Knowledge Outputs could exist within one deliverable, and should be separated. *Try to give a comprehensive description, making the Knowledge Output fully understandable to a non-expert.* *If relevant please provide detail of where the Knowledge Output differs from its equivalent, e.g. What are the key characteristics of the Knowledge Output? What research is it adding to and what is innovative about the Knowledge Output? (Max 500 characters).*	Date: 28 September 2020 Institution: CSIC – UPC Literature indicates that MAR removes chemical and microbiological contaminants eliminating about 2.5 Log of coliforms, 35% of chemical oxygen demand, and between 66% and 100% for many chemical contaminants. These achievements are equal or better than those provided by UV radiation, ozonation, and nanofiltration, and the total capital costs of the MAR system is lower.
Knowledge Type	* Review-scientific publication
Link to Knowledge Output	https://camins.upc.edu/es/estudios/tfe/deposito?set_language=es

Sectors & Subsectors
Choose as many options as required from the list. Pick those sectors that you think would benefit from the application of this Knowledge Output.
	• Basin Management
	• Water Scarcity and Droughts
	• Drinking Water
	• Emissions and Water Reuse
	• Adaptation to Global Change
	• Others
	  o Agriculture
	  o Governance
	  o Finance
	  o Socio-Economics
	  o Stakeholder Involvement

End User *Per identified End User, please identify possible applications of the Knowledge Output.*	o Education & Training o Environmental Managers & Monitoring o Industry o Policy Makers / Decision Makers o Scientific Community o Civil Society
IPR.	nla
Policy-Relevance If the Knowledge Output is relevant to the WFD or any other related Directives, please list and explain why	The contributions will favour the development, implementation, and enforcement of EU environmental and climate policy and legislation boosting the integration of environmental and climate objectives into other EU policies, such as the **new Regulation 2020/741 on water reuse** and

	to **reach zero environmental contamination** stated in the **European Green Deal**. The findings can be integrated into or modify current EU directives, namely the **Water Framework Directive 2000/60 and the daughter groundwater Directive 2006/118.** Considering that the use of regenerated water in agriculture must be in accordance with Annex I of the new Regulation 2020/741, the wastewater used as source water must fulfil the **wastewater Directive 91/271/CEE.** However, if the system provides outstanding performance in removing CECs, the **Directive 91/271/CEE could be amended considering the proposed water regeneration approach.**
Status *Please identify whether the Knowledge Output is finalised, is still being generated or whose status/future is unknown. Consider:* *• Is your knowledge conclusive enough that it provides sufficient evidence to make an impact on, or be applied by, an End User?* *• Is there a corroborating body of evidence, or are contradictory results, available?* *• Does your knowledge progress beyond the current state-of-the-art / evidence base?* *• Is more research or demonstration needed to validate the results?*	Finalized

Knowledge Output 4

Short Title	Master course
Knowledge Output Description *Please only include generated Knowledge Outputs, not those that are expected. Note: Knowledge Outputs can be non-deliverables, milestones or 'grey knowledge'. Also, multiple Knowledge Outputs could exist within one deliverable, and should be separated.* *Try to give a comprehensive description, making the Knowledge Output fully understandable to a non-expert.*	Master Program: Environmental Engineering – Polytechnics University of Catalonia (UPC) Yearly since 2017 to date Subject: Organic pollutants in aquatic ecosystems and environmental seu.CSIC-UPC Lecturers and subject:

If relevant please provide detail of where the Knowledge Output differs from its equivalent, e.g. What are the key characteristics of the Knowledge Output? What research is it adding to and what is innovative about the Knowledge Output? (Max 500 characters).	Silvia Díaz- Cruz. Emerging Organic Pollutants Paula Rodríguez. Transformation of organic contaminants in the subsoil. Cristina Valhondo. Behavior of organic pollutants during the reuse of wastewater in the aquifers recharge
Knowledge Type	* training activity/learning module
Link to Knowledge Output	https://camins.upc.edu/es/estudios/master/mia
Sectors & Subsectors	• Others o Other General
End User	Education & Training
IPR	nla
Policy-Relevance	no
Status	Still being generated

Knowledge Output 5

Short Title	Master course
Knowledge Output Description *Please only include generated Knowledge Outputs, not those that are expected. Note: Knowledge Outputs can be non-deliverables, milestones or 'grey knowledge'. Also, multiple Knowledge Outputs could exist within one deliverable, and should be separated.* *Try to give a comprehensive description, making the Knowledge Output fully understandable to a non-expert.* *If relevant please provide detail of where the Knowledge Output differs from its equivalent, e.g. What are the key characteristics of the Knowledge Output? What research is it adding to and what is innovative about the Knowledge Output? (Max 500 characters).*	Master Program: Analytical Chemistry. University of Barcelona (UB) Yearly since 2017 to date Subject: Study of organic pollutants in most environmental and environmental effects. CSIC-UB Lecturer and subject: Silvia Díaz- Cruz. Emerginf organic contaminants
Knowledge Type	* training activity/learning module

Link to Knowledge Output	https://www.ub.edu/portal/web/quimica/masters-universitaris/-/ensenyament/detallEnsenyament/1966862/25
Sectors & Subsectors	• Others ○ Other General
End User	Education & Training
IPR	nla
Policy-Relevance	no
Status	Still being generated

9. Open Data

In relation to Open Data, the funded projects will be requested to submit metadata on all the resources directly generated by the project, as well as additional information on how these data will be exploited, if and how data will be made accessible for verification and re-use, and how it will be curated and preserved. Metadata on all project resources are required to be submitted as part of the final reporting. This will be done via the **Open Data & Open Access platform**, available at: http://opendata.waterjpi.eu/ (also accessible from the bar menu of the Water JPI website).

10. Problems Encountered during Project Implementation

COVID-19 hindered and still impacts all the work related to pilot and field MAR. Recharge events were postponed for months until we were allowed to move across Catalonia (Spain) and to have the permits to access the WWTP. This also delayed the dismantling of the barriers and subsequent assembly with the new materials, still to be performed.
The viability studies to select the most suitable WWTP to build the MAR system at a real scale were also delayed.

Due to the COVID-19 lockdown, the experimental work at the laboratory was first suspended, and slowly partially rebooted because of the limitation in the number of analysts working at the same place, for all partners.

In connection with experimental work, personnel hiring was also dramatically affected by the pandemic.

For the CNRS partner, a total confinement period has been imposed to everybody from March, 15th to May, 11th 2020. After May, 11th a partial confinement was still imposed, and a more regular situation has been established since September 2020. Consequently, very few tasks have been achieved during this period and even after as we were depending of other partners from the consortium where the national situation concerning the COVID-19 pandemic was different or delayed from France.

The research activities of Partner IRSA-CNR were detrimentally affected by the lack of active funds at national level. However, the implementation of the results was focused on the baseline consolidation of current knowledge to promote the advanced methodological applications within the context of this project. Moreover, Dr. Caterina Levantesi resigned from her responsibilities as local coordinator due to health and personal reasons partly linked and aggravated by the current pandemic. Dr. Stefano Amalfitano, already part of the team, was officially designated as principal investigator. The official signed documentation was requested and sent to the national contact point on October 12, 2020, although the new PI took the lead already by the end of May 2020 to coordinate the agreed analytical and project activities. Despite not officially engaged at this stage, a new team member from IRSA-CNR was already contacted to provide specific support on biomolecular analysis and pathogen identification. The final acceptance is expected to arrive shortly, which will be communicated by the Coordinator to the JPI Secretariat.

11. Suggestions for improvement regarding project implementation?

Extension of the execution time, 6-9 months to satisfactorily achieve milestones, and provide the expected deliverables.