Project: Managed Aquifer Recharge: Addressing the Risks of Recharging Regenerated Water

MARadentro

Outcomes and expected impact:

MARadentro will fill a knowledge gap as well as a regulatory gap for MAR technology to contribute to closing the water cycle gap. Specifically, MARadentro will develop a knowledge base for understanding, preventing and mitigating the risks associated to MAR implementation, to make MAR a reliable technology for water management adapted to the emerging water challenges. The incorporation of novel reactive layers will ensure MAR as 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. The economic analysis 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 to help develop water policies closer to end-users needs. General public acceptance about MAR is expected providing a firm scientific basis and an open access to the outcomes. The technological readiness level from several multidisciplinary approaches and applications will be improved, reaching a MAR prototype close to market.

MARadentro main outputs are listed below:

- Publications
- Contributions in Conferences
- Webinar.
- Stakeholders meetings.
- Lectures in Master courses.
- Master and PhD Theses.
- Sofware applications and models.
- Monitoring tools for pathogens
- Events at MAR field site for stakeholders, schools, and the public to increase awareness

- A TV documentary about water resources, closing the water cycle gap and MAR technology.
- A protopype of the reactive barrier developed.
- for the prototype of the reactive layer.
- Provide a success case of market ready solution (with patent if possible), in order to boost the replication in other regions and transferability to other sectors.
- Provide economic and environmental impact of a full scale indirect potable water reuse scheme with MAR optimized design.
- Increase the understanding of water quality improvement processes during MAR, and specifically the conditions for effective removal of pollutants and retention of pathogens, thus contributing to integrated water resources management (IWRM).
- Formalize and demonstrate the benefits of MAR and the requirements on MAR design, construction and operation to guarantee a high quality effluent.
- Evaluate alternative early warning tools for rapid assessment of microbiological water quality ameliorations in MAR.
- Suggest realistic EU recommendations favouring implementation of MAR while avoiding its potential risks.
- Improve chances for economic development of all economic sectors as a result of an increase on water availability and increased resilience to water stress conditions.
- Promote the positive perception to water reuse and MAR by the general public (social acceptance).

Expected research results to communicate and disseminate (in very general terms)	**Target groups for communication and dissemination activities:**
1. Organization of two meetings with stakeholders, at the beginning and at the end of the project. This includes events at our pilot MAR and field scale MAR site. 2. Development of a guideline to be disseminated to the water companies and water end-users.	End-users
3. Development of a **set of "recommendations for regulators"** for the European Parliament. These recommendations will be transferred to the **JRC** (a stakeholder of the project) and to local and regional water administrations (stakeholders of the project).	Policy makers
4. Production of scientific papers published in Web of Science indexed journals. The publishing politics will be open access.	Scientific Community

5. Lectures in Master courses in UPC and Montpellier University (MU). 6. Communication in scientific conferences. Special sessions will be organized towards the end of the project at the major scientific meetings in the fields of geosciences and environmental toxicology and chemistry. 7. Communication of project metadata in the webpage of MARadentro.	
8. We will develop a Webpage, where we will publish all the project results and events. This webpage also will serve as a repository of all the data generated by the project. 9. A Webinar will be organized during the second year of the project. It will be open to general public, but stakeholders will be specially invited to attend. 10. A TV documentary will be produced. Especial emphasis on local TVs	General public
Experiments / Case studies (if any): location, type of experiments:	<u>Column experiments</u> will be carried out to test and calibrate the performance of different layer compositions. Microbiological, toxicity and chemical analyses will be used to evaluate the performance of the tested layers and systems for the removal of pathogens and chemical contaminants. Leader partner: CNRS. <u>Pilot scale MAR</u> located in Palamós WWTP (close to Barcelona). The facility consists of 6 recharge areas (2.4 m^2) connected to 15 m. long sediment tanks that emulate the aquifer. The system allows biomass augmentation, addition of organic carbon sources and adsorbing chemical species. The use of real wastewaters in the pilot MAR will allow a realistic

	understanding of pollutants behaviors, largely influenced by source water physical, chemical and microbiological characteristics, in a complex fluctuating environment. For a more integrated approach, microbiology, toxicity and chemical analyses will be performed to describe the functionality of the reactive layers as well as to evaluate the performance of the pilot MAR for the removal of pathogens and chemical contaminants. Leader partner **CSIC.** Field MAR. The MAR technology will be implemented at a WWTP where the feasibility of our solution will be assessed under long-term operation. The design, construction and evaluation will be led by MARadentro industrial partner AQUALIA in close collaboration with the other partners. Two alternative demo sites are proposed since the decision must be made based on the site suitability: WWTP Riera de la Bisbal (El Vendrell, Baix Penedés, Tarragona, Spain) and WWTP Borja (Zaragoza, Spain). A borehole will be drilled with core extraction to verify the suitability of the sediments column and a pumping test will be performed to verify the suitability of the aquifer. Both WWTPs have secondary and tertiary treatment through conventional filters so that the suitability of the MARadentro process can be tested using either secondary or tertiary source water, which implies an added value to the validation since the comparison will be able to confirm also at technical level (EOCs and pathogens removal) as well as at economic;

	amortization of the investment and maintenance costs of both systems. Leader partner AQUALIA**.**
Water Policy context / project contribution to policies (National, European, International – UN SDGs):	MarAdentro aims to increase the benefits of MAR regarding water quality and to minimize the associated risks by developing affordable and effective technologies through reactive layers implementation. Besides, based on the knowledge gained, MarAdentro will provide recommendations/guidelines for a future regulative scenario regarding the reuse of reclaimed water for MAR. Therefore, in connection with the scope of the Water JPI call 2018, the project fulfils Sub-theme 1.2. "Integrative management by implementing NWRM such as MAR". Moreover, MarAdentro also addresses Sub-theme, 2.1. "Integrating economic and social analyses into decision-making processes", regarding the evaluation of economic viability of the system implementation at field. Finally, the project is strongly related with the Sub-theme 2.2."The reuse of water", as MarAdentro address social acceptance for the reuse of reclaimed water, economic feasibility and the removal of pathogens and pollutants considering cost-effective technologies. MarAdentro will contribute to reach UNSD Goal 6 targets, i.e. improve water quality, increase water-use efficiency, and protect/restore aquatic ecosystems. UNSD Goal 13 targets are also addressed; specifically integrate climate change measures into national policies, strategies and planning to strengthen resilience and adaptive capacity to climate-related hazards.

List of deliverables expected: (by WP)
D1.1 Consortium agreement signed; **D1.2** Mid-term report**;** **D1.3** Final report**.**
D2.1. Report on microbial populations, fecal contamination indicators, pathogens and EOCs in MAR systems.
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.
D4.1 Water microbial community characteristics and fecal contaminants levels variations in layers and sediment tanks, and identification of specific microbes; **D4.2.** Elimination rates of selected EOCs and degradation/transformation products identification.
D5.1. Site characterization report; **D5.2.** Project of the industrial prototype to be built; **D5.3.** As-built report; **D5.4** Industrial MAR prototype performance.
D6.1 Mathematical formulation for EOCs/pathogen transport; **D6.2.** Modeling of experiments at different scales; **D6.3** Risk assessment of MAR concerning the fate of EOCs and pathogens and modeling tools to upscale MAR systems.
D7.1 Construction cost and replicability report**;** **D7.2** Economic impact, market trends and technology report.
D8.1 Webpage; **D8.2.** TV documentary**;** **D8.3** Recommendations for decision-makers**.**