RECHARGE

The MARSOL Newsletter • Issue 05

Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity & Drought

The Project

The Mediterranean region is suffering from increasing water scarcity, which is further exacerbated by climate change, high population density, and high water consumption by agricultural, industrial, and urban uses. Not only quantity but also quality is of increasing importance, e.g. due to intensive use of fertilizers and seawater intrusion. Meanwhile, large water quantities are lost to the Mediterranean Sea as surface runoff, river discharge, discharge of treated and untreated wastewater, and as discharge of excess water from various sources during periods of low demand. This water can be used in principle for the controlled (re-)filling of exploited aquifers by artificial infiltration, referred to as Managed Aquifer Recharge (MAR).

21 PARTNERS

SINCE DECEMBER 2013
36 MONTHS

TOTAL BUDGET
€8 MILLION

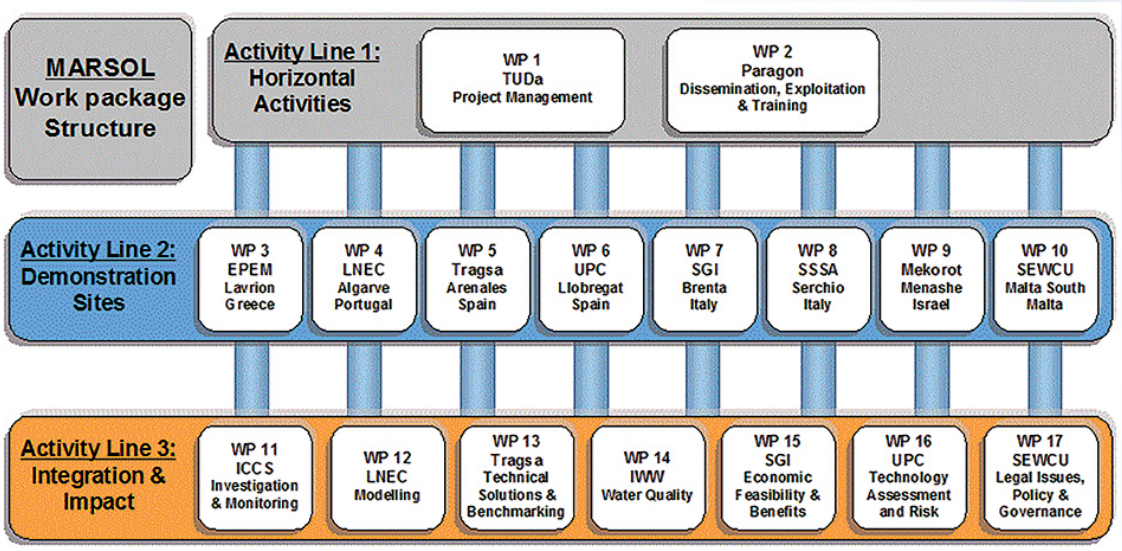
EU CONTRIBUTION
€5.2 MILLION

Project Objectives

MARSOL is an FP7 project which aims to demonstrate that Managed Aquifer Recharge (MAR) is a sound, safe and sustainable strategy that can be applied with great confidence. MARSOL aims to stimulate the use of reclaimed water and other alternative water sources in MAR and to optimize water resources management through storage of excess water to be recovered in times of shortage or by influencing gradients.

- Demonstrate at 8 field sites that Managed Aquifer Recharge (MAR) is a sound, safe and sustainable strategy to increase the availability of freshwater under conditions of water scarcity
- Improve the state of the art of MAR application to enable low-cost, high efficiency MAR solutions that will create market opportunities for European Industry and SMEs
- Promote the advantages of MAR by tailored training and dissemination programme to enable and accelerate market penetration
- Deliver a key technology to face the challenge of increasing water scarcity in Southern Europe, the Mediterranean and other regions of the world

Work Package Structure



MARSOL Partners

Technische Universität Darmstadt, Darmstadt	TUDa	Germany
Institute of Communication and Computer Systems, Athens	ICCS	Greece
Laboratório Nacional de Engenharia Civil, Lisbon	LNEC	Portugal
Empresa de Transformación Agraria S. A., Madrid	Tragsa	Spain
Universitat Politècnica de Catalunya - BarcelonaTech, Barcelona	UPC	Spain
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Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna, Pisa	SSSA	Italy
Mekorot, Israel's National Water Company, Tel Aviv	MEK	Israel
Sustainable Energy and Water Conservation Unit	SEWCU	Malta
EPEM S.A. – Environmental Planning, Engineering & Management, Athens	EPEM	Greece
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Agricultural Research Organization - Volcani Center, Beit Dagan.	ARO	Israel
Water Services Corporation, Luqa	WSC	Malta
Paragon Europe, Mosta	PRN	Malta

Demo Sites

Lavrion Technological & Cultural Park, Greece
Development and implementation of advanced sensors

Algarve and Alentejo, Portugal
River water infiltration at three sites

Arenales, Castilla & Leon, Spain
River water infiltration, Soil Aquifer Treatment (SAT)

Llobregat River, Catalonia, Spain
River water infiltration basin

River Brenta Catchment, Vicenza, Italy
Forested infiltration area for aquifer storage and recovery (ASR)

Serchio River Well Field, Tuscany, Italy
River bank infiltration with an advanced monitoring network

Menashe Infiltration Basin, Hadera, Israel
Aquifer storage of surplus water from the Hadera desalination plant

South Malta Coastal Aquifer, Malta
Create a seawater intrusion barrier at a coastal wastewater treatment plant

Demo Site2

Algarve and Alentejo, South Portugal

Teresa E. Leitão[1], J.P. Lobo Ferreira[1], Tiago Carvalho[2], José Paulo Monteiro[3], Manuel M. Oliveira[1], Rui Agostinho[2], Luís R.D. Costa[3], Maria José Henriques[1], Tiago Martins[1], José Martins de Carvalho[2]

The main objectives of the MARSOL project are to demonstrate how MAR can contribute as an alternative source of water, in the context of an integrated and inter-annual water resources management, as well as in solving groundwater quality problems. In the case of Demo Site 2, Algarve and Alentejo, South Portugal, the latter are mainly caused by inadequate agricultural practices and wastewater discharges.

The alternative water sources explored under MARSOL in Portugal are surface water surpluses generated during rainy seasons and wastewater effluent with secondary treatment. Both have been studied to assess the volumes available and their significance in the regional water budget context, and their quality. One of the aspects being studied is the feasibility of using karstic aquifers as a facility for large-scale storage of alternatives water sources. The best approaches for aquifer recharge, which include water quantity and quality monitoring and purification by natural attenuation and filtration processes from Soil Aquifer Treatment (SAT), are the focus of the following PT demo sites

- PT1: Rio Seco and Campina de Faro aquifer system (Algarve)
- PT2: Querença-Silves limestone karstic aquifer system (Algarve)
- PT3: Melides aquifer, river and lagoon (Alentejo).

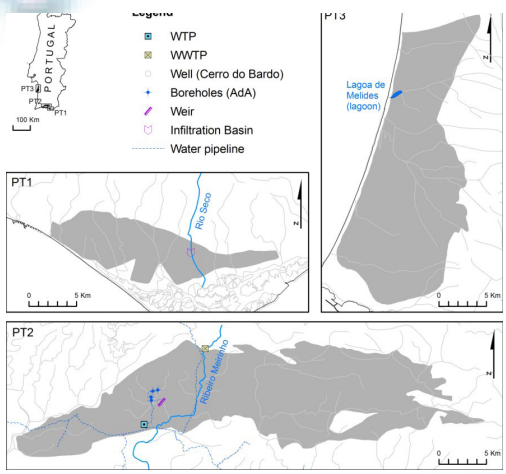
PT1 aims to demonstrate that the aquifer water quality can be improved by means of MAR. For this purpose, infiltration basins constructed in the Rio Seco riverbed are being tested and monitored, using either the basins constructed in 2006 during GABARDINE EU project (PT1_1), which were rehabilitated during MARSOL, or the new MARSOL basins (PT1_2) constructed in July/August 2014. Furthermore, infiltration in typical existing large-diameter wells (PT1_3) is being tested as a potential MAR facility to increase the water recharge at a regional scale and improve the groundwater quality status, using the water collected in the greenhouses roofs during rain events.

The rehabilitation of the structures inherited from the GABARDINE EU project (2005-09) in Rio Seco - Campina de Faro took place between 25th and 26th July 2014. They consist of two infiltration basins - with approximately 20 m long, 5 m wide and 6 m deep.

The constructed MARSOL basin has an average depth of 6.7 m, a total length of 33 m and occupies the entire cross section of the river, with an average width of 6.1 m at the surface (cross-section of the river varying between 5.5 to 6.2 m). This basin has a surface area of 201 m2 (33 m x 6.1 m). Vertically it presents a perfectly rectangular configuration (vertical slopes) across its lateral extent (Fig. 2).

Several piezometers and wells were installed. These infrastructures aim to control and monitor the injection tests performed at Rio Seco, in both MARSOL's and GABARDINE´s infiltration basins (dug in the upper aquifer), and to improve the geological knowledge of the MARSOL basin area.

Upon the completion of the infiltration basins work, several tests were performed in order to evaluate the performance of the basins in terms of clogging, infiltration rates and its local influence in the groundwater quality. Besides, a test was conducted in a large diameter well to assess its infiltration rate capacity.



▲ Fig. 1. Location of the PT MARSOL demo sites (Leitão et al., 2015)

River basin excavation: August 2014

River basin filling: August 2014

▲ Fig. 2. Construction of a new MARSOL infiltration basin and new monitoring piezometers at PT1_2 Campina de Faro (Leitão et al., 2015)

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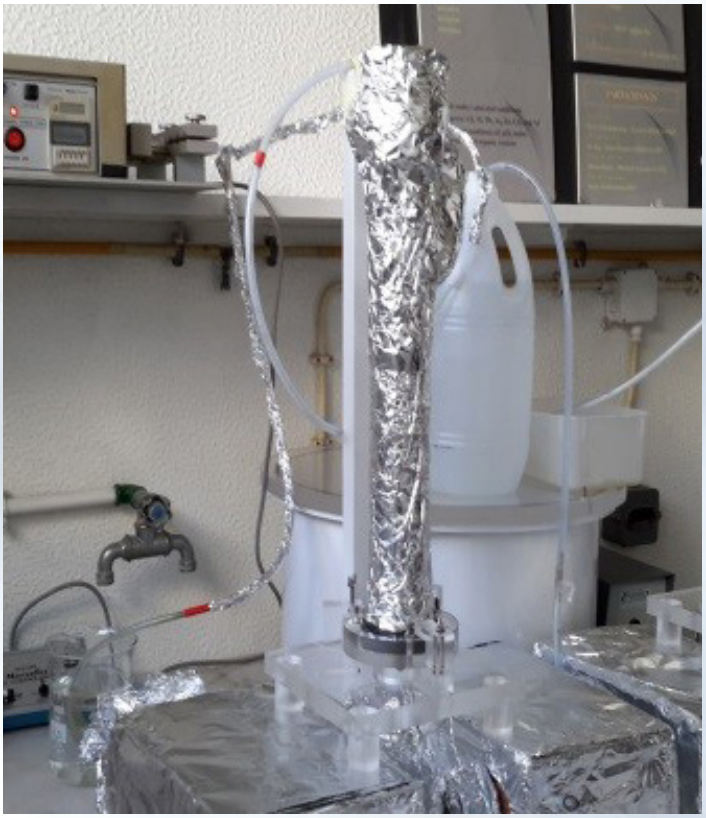
▲ Fig. 3. Sampling the WWTP for water collection WP14 at PT2_4 – WWTP SB Messines

The following tests were performed:

- PT1_1: Clogging test in one GABARDINE basin, 1st July, 2014
- PT1_1 and PT1_2: Infiltration test in all three basins, 29-30th September, 2014
- PT1_2: Tracer test in MARSOL basin, 13-14th October, 2014
- PT1_3: Infiltration in large wells, 1st October, 2014
- PT2_6: Infiltration in large wells, 1st April, 2014

Oliveira et al. (2015) present the results of the clogging test conducted on 1st July, 2014. Costa et al. (2015) show the interpretation of an injection test in a large diameter well conducted on 1st April, 2014.



▲ Fig. 4. LNEC soil-column experimental setup

PT2, Querença-Silves limestone karst aquifer system (Algarve) Demo Site aims to: (1) develop a SAT system to improve the water quality of treated effluents from a WWTP (PT2_4), which discharges water into Ribeiro Meirinho river (PT2_5) and (2) increase groundwater storage using MAR to recharge surplus of surface water during wet years at Cerro do Bardo well (PT2_6), located next to a tributary of Ribeiro Meirinho. This will contribute to increase the water availability in dry years, facilitating downstream water supply pumping.

During 2014 and 2015, the work developed in PT2_4 consisted in the characterization of the treated wastewater effluent in several different occasions (Fig. 3), as well as the development of several soil-column tests in LNEC laboratory facilities (Fig. 4) to determine the pollutants removal capacity of local soils. Martins et al. (2015) and Martins (2016) present the results of the performed soil-column tests.

▲ Fig. 5. Cerro do Bardo well and Aivados dam (Leitão et al., 2015)

The work developed in PT2_6 Cerro do Bardo site (Fig. 5) consisted in the rehabilitation of an existing small dam at Aivados and the private owned Cerro do Bardo well. This work took place between November 10th and 19th 2014. The location of the construction work is Barranco de Aivados, located close to Cerro do Bardo, at approximately 4 km NW of Algoz, specifically in the parish of Alcantarilha / Silves.

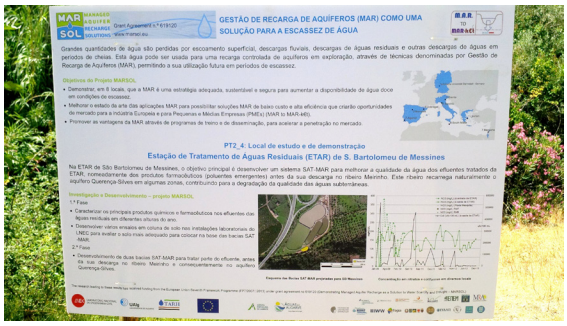
The objective of Cerro do Bardo Site is to investigate and conceptualize the possibility of enhancing the regional water management by using surface water and MAR Techniques to increase groundwater availability, possibly enhancing water supply wells productivity.

Demo Site3

The preferred water flow direction of the infiltrated water in the aquifer was assessed through an injection and tracer test done in April and December 2014, respectively. Preliminary results of tests in the Cerro do Bardo (PT2_6) large diameter well suggest adequate conditions for installation of a MAR site, considering the large diameter well is characterized by high infiltration rates.

The following tests were performed:

- PT2_4: Assessment of WWTP quality, May and September, 2014
- PT2_6: Quantitative infiltration test, 1st April, 2014
- PT2_6: Quantitative infiltration test, 15-19th December, 2014
- PT2_6: Quantitative and qualitative large (45 L/s during 90 hours) infiltration test, 20-24th April, 2016



▲ **Information board at the MARSOL demo site PT2_4 near São Bartolomeu de Messines, Portugal**

In PT1 Rio Seco and Campina de Faro aquifer system (Algarve), injection and tracer tests have been done to determine basins infiltration rates, and velocity and dispersion in the aquifer. In that Demo Site, a continuous monitoring of all system is now in place to assess the effect of all precipitation episodes and their influence in the infiltration basins and the aquifer.

In PT2 Querença-Silves limestone karstic aquifer system (Algarve), injection and tracer tests have been done to determine a large well's infiltration capacity and the main groundwater flow direction. Besides, several soil-column experiments were performed to determine, at lab scale, infiltration rates and soil removal capacity for some nutrients, toxic metals, metalloids and pharmaceutical originated from wastewater, and prior to MAR.

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ARENALES, CASTILLA Y LEÓN, SPAIN

Enrique Fernández Escalante, Rodrigo Calero Gil, Francisco de Borja González Herrarte (Tragsa); María Villanueva Lago (Tragsa); Jon San Sebastián Sauto (Tragsatec)

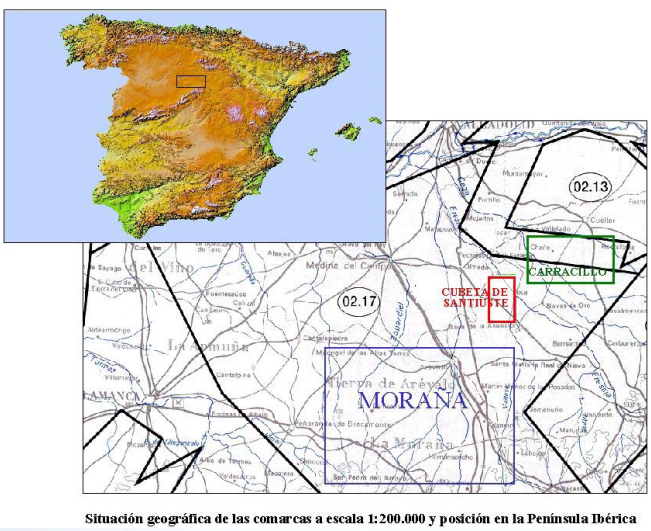
The principal aim of the work conducted at the demo sites in Spain's Castile and León region is to demonstrate the efficiency of MAR in an irrigation area with a large development of agro-industry, in order to provide technical solutions by means of permanent research. Focussing on the Los Arenales aquifer, MARSOL partner Tragsa is coordinating all efforts at the sites, counting on the collaboration of Tragsatec technicians, a branch of Tragsa Group. The Los Arenales site is the biggest demo site within the MARSOL project, so it could be considered a 'macro' demo site.

The objectives of the tasks within the structure of the MARSOL project has been three fold:

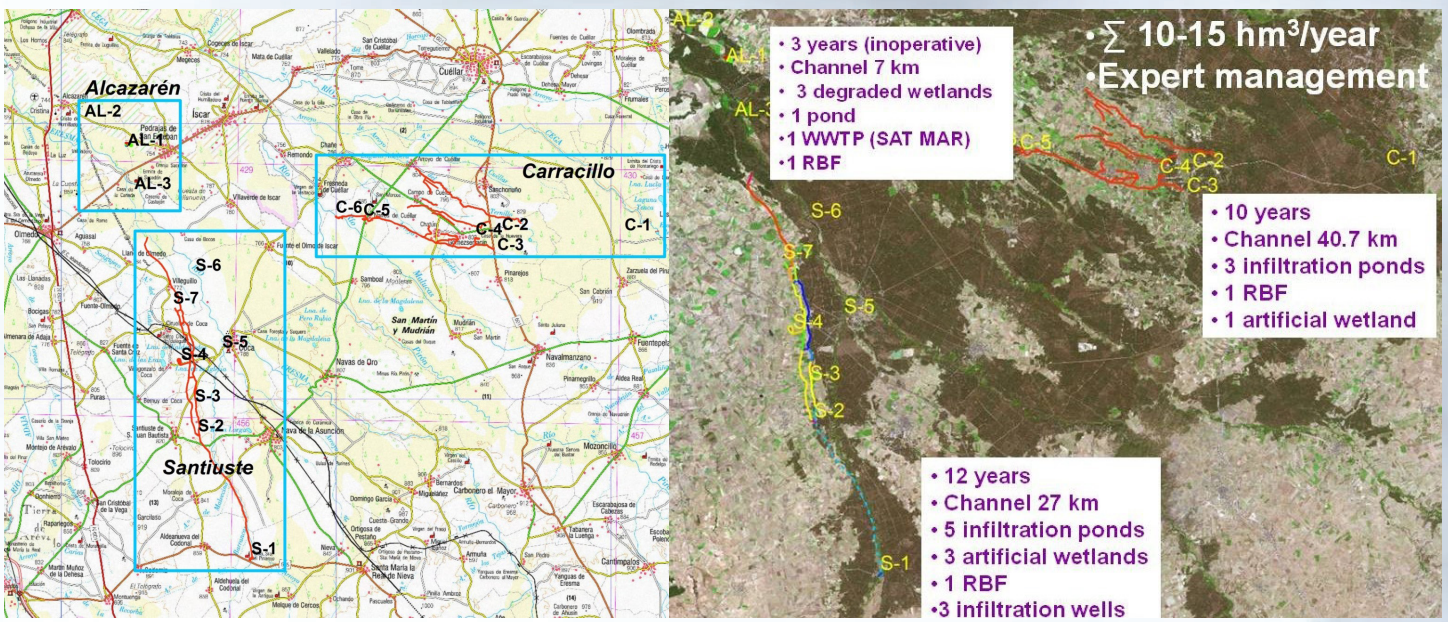
- The main goal is to describe the current situation of the Los Arenales case, taking into account that it involves three separate sites.
- Explain the challenges to be solved at the demo sites, to develop their different tasks and objectives. The improvements at the demo sites are described, not only dealing with constructive details, but also in relation to the communication with stakeholders.
- Actions to achieve public participation and deeper education of the farmer groups are defined. These activities, directed to bring MAR technique to the market (with focus on the agro-industry) and to solve the actor's needs by means of technical solutions, have been initiated right from the beginning of the project.

Table 1 Main components of the Los Arenales aquifer

Demo Site	Operability (years)	MAR canal (km)	Infiltration ponds	Infiltration wells	Artificial wetlands	RBF	SAT-MAR
Santiuste	12	27	5	3	3	1	1
Carracillo	10	40,7	3	?	1	1	0
Alcazarén	3	7	1	0	3	1	1



▲ **Fig. 1. Los Arenales aquifer and its position in Spain. Scheme not to scale.**



▲ **Fig. 2, Fig. 3. Los Arenales Aquifer MAR facilities, position and layout of the facilities on the topographic map (Fig. 2) and on the orthophoto (Fig. 3) with a list of the main MAR components. Approximate scale: 1:150.000.**

The activities are accomplished at three local zones. Santiuste basin and Carracillo district (both in the Segovia province) are sites with a sound long experience on MAR applications. The third area, Alcazarén (in the Valladolid province), is a pure SAT-MAR scheme.

The Los Arenales aquifer is located in the southern sector of the Duero Basin. Its surface spreads over 7,754 km2 and includes some parts of the provinces of Salamanca, Valladolid, Segovia and Ávila. The main rivers that run across this aquifer are Duero, Zapardiel, Adaja, Eresma and Voltoya (Figure 1). Its origin is polygenic with a predominance of Arevalo facies, i.e. Quaternary dune system sands, filling a complex substrate from the Miocene epoch, notably argillaceous (Cuestas) or arenaceous and argillaceous (Puente Runnel), with a thickness up to 56 m. A detailed description can be found in the hydrogeological literature (Alcalá del Olmo, 1975; MIMAM, 2002; Fdez. Escalante, 2005).

The intensive exploitation of groundwater in some areas of the Los Arenales aquifer has caused an outstanding decrease of its phreatic levels. In reaction to this and in order to minimize environmental effects, the Ministry of Agriculture (MAPA) of the Spanish government planned to carry out several Managed Aquifer Recharge activities in this groundwater body, using water surpluses from the Voltoya, Cega, and Eresma rivers, respectively. The activities also included small volumes of treated waste water. Most of the studies conducted and the references mentioned in the area have been performed by Tragsa Group by direct assignment of the Spanish Ministry of Agriculture. Authors of the vast majority of the studies and references are also active members of the MARSOL consortium.

Figures 2 and 3 give an overview of the location and MAR components of the three sites, while Table 1 summarizes the main components of the MAR facilities. All components and sites are part of the demonstration activities of the MARSOL project.

The main conclusions on are:

- The demo site features abundant, diverse and successful examples of MAR implementation.
- There are remarkable instances of water management and energy efficiency improvements by means of the MAR technique.
- The future target is linked to a supply guarantee without climate dependence – to achieve this, reclaimed water has to be integrated.
- There are significant varieties of scales at stakeholders level, from individual farmers to big industries.
- The water footprint is really high; huge amounts of green water are being exported abroad with the fruits and vegetables produced.
- The SAT techniques applied are appropriate and their effectiveness is increasing cycle after cycle.
- There are plenty of good cases of water management conducted by end-users, based on appropriate technical advice.
- One of the biggest impacts on MAR operations is clogging and an important goal will be to reduce the gas clogging in MAR water and bubbles trapped in the aquifer by preventive means.
- It is important to carry out activities on the receiving medium (soil) to increase the infiltration rate and to increase the life-span of the facilities.
- Management parameters are also very important to achieve good results, e.g. to check the period and the MAR flow rate to achieve maximum infiltration rates.

MARSOL Activities

- The most important operation regarding water quality is the water pre-treatment. The bigger the quality of the source water is, the better the results are.
- It is also imperative to listen to specialists and strengthen relations among technicians / farmers / regulators as well as to keep alert on new publications and achievements in other parts of the world.

General conclusions on problems and solutions of MAR techniques are:

- The Environmental Impact Assessment approach shows the double face of MAR as a human activity. The assorted techniques are mainly used to solve problems while they also provoke others. Fortunately most of the possible impacts can be mitigated by choosing options provided by the same MAR methodology.
- MAR techniques have a great ability to reuse old infrastructures (quarries, mines, sand pits, old ditches...) so they can be transformed not only into recharging facilities but most of the times into new ecological hot spots (artificial wetlands).
- The low cost of reusing pre-existent infrastructure as well as performing recharge with no energy cost (gravity transport and passive infiltration) and low land use (subterranean storage) are relevant issues when adopting the Water Framework Directive related to water management costs.
- The profits overcome the inconveniences as a general rule. That is the main reason why successful schemes should be exported to equivalent areas, prompting a 'domino effect'.
- It is important to disseminate encouraging examples and successful cases from other experiences around the world among those stakeholders who provide real help in the MAR facilities management.

Taken from:
MARSOL deliverable 5-1: Los Arenales demonstration site characterisation Report on the Los Arenales pilot site improvements

MARSOL deliverable 5-2: Problems and solutions found at "Los Arenales" demonstration site

MARenales movie:
- **DINA-MAR:** http://www.dina-mar.es/videos/MARenales-Film_v7.6.mp4
- **Youtube:** https://youtu.be/Dw22rcEQdiw

Demo Site4

Llobregat River Infiltration Basins, Sant Vicenç dels Horts, Catalonia, Spain

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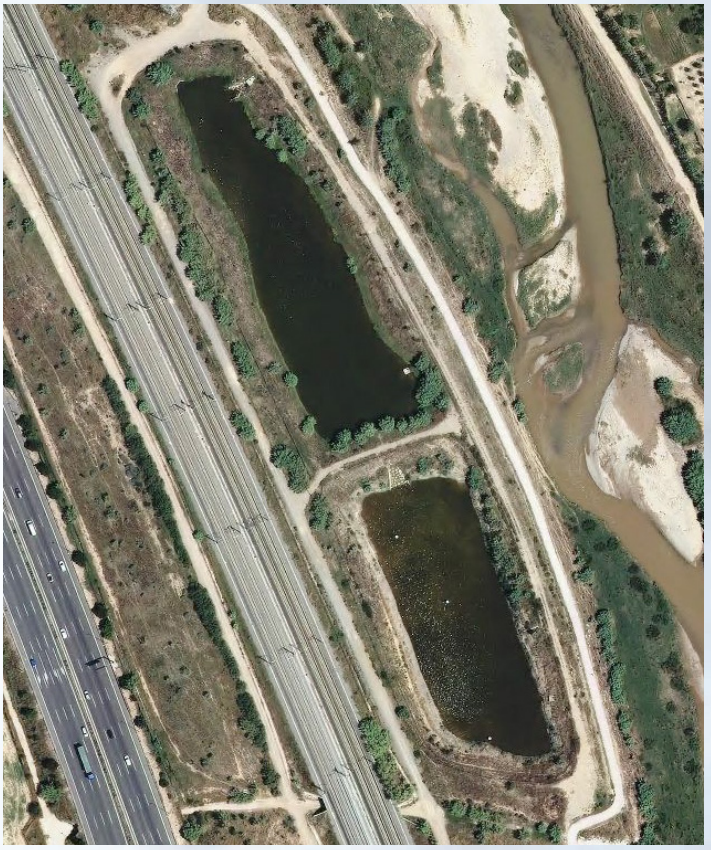
The main goals planned for the Llobregat recharge facility were restoring water levels felt by the historical over-exploitation suffered in the Lower Valley Aquifer, in the context of Barcelona Conurbation development.

This MAR site, located in Sant Vicenç dels Horts -15km from Barcelona - is composed by one 7000 m2 settlement pond followed by a 4500 m2 recharge pond. Water is diverted from the Llobregat River 3 km upstream towards the settlement pond. After a few days of residence, water passes through a connecting pipe to the recharge pond.

The system started operating in 2009. A reactive layer was installed at the bottom of the recharge pond in 2011. It has been demonstrated that such a layer induces microbial activity and results in enhanced decontamination efficiency at the expense of reducing the infiltration rate.

In the context of the MARSOL project, a large number of activities have been performed or else are planned for the future:

- Hydrochemical and microbial communities characterization to compare dry and flooding scenarios in order to distinguish their distinct contribution to bioclogging formation; this includes:
    1. hydrochemical analysis of water samples,
    2. cluster analysis of system microbiology and calculation of Diversity and Richness Indexes for each sample,



▲ Arial view of the MAR site (2015)
Source: Institut Cartogràfic i Geològic de Catalunya

▲ Infiltration pond-Sampling campaign, July 2014

3. monthly monitoring of dissolved oxygen, redox potential, temperature and electrical conductivity at depth, at several piezometers,
4. continuous monitoring of water table temperature and electrical conductivity in all the existing piezometers.

- Approach of the conceptual model of the carbon cycle as a base to understand reactive layer dynamics.
- A lab experiment to simulate recharge and drying events to understand:
  1. oxygen behavior in the soil profile,
  2. bioclogging formation by changes in the infiltration rate after flooding periods and after scrapping the tank floor.
- Modelling of emerging organic compound degradation behavior under different pumping conditions, with emphasis on the fate of the antibiotic sulphamethoxazole responding to changes in redox conditions as an illustrative example.
- Development of probabilistic risk methodology linked to MAR
  1. definition of potential compounds that can lead to system failures,
  2. fault tree construction.

▲ Groundwater sampling, March 2015

▲ Sedimentation pond, March 2015

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MARSOL Deliverables

In this and the following newsletter, we introduce selected deliverables which represent a cross section of the MARSOL project's work and achievements. All public deliverables can be downloaded as full texts from the 'Results' section of the MARSOL website – www.marsol.eu.

Deliverable 9.1 "Development of monitoring system, sampling & characterization of the Menashe demonstration site, Israel"

Authors: Daniel Kurtzman (ARO), Yonatan Ganot (ARO) Amos Russak (ARO), Ido Nitzan (ARO), Anat Bernstein (BGU), Yoram Katz (MEK), Yossi Guttman (MEK)

At the Menashe demonstration site, Israel, the ongoing MAR activity aims both at seasonal storage and ASR (aquifer storage and recovery) of surplus desalinated sea water from a nearby desalination plant. The main focus of the research and demonstration activities presented in this report is on the installation of a monitoring system in the unsaturated zone and shallow aquifer, the sampling and investigation of soil and water, and a comprehensive site characterization.

The Menashe infiltration basins are located on sand dunes overlaying Israel's coastal aquifer. The report gives some results on the soil composition from drillings and the installation of observation wells down to depths of 30 m. Hydrochemical data are reported for the three types of water connected to the MAR activity: The desalinated water to be infiltrated, the shallow groundwater right beneath the infiltration basin, and the deeper groundwater of the aquifer. Of the characteristics of the desalinated water, especially the extremely low magnesium content and the – compared to the groundwater – high boron content should be noted. The different geochemical reactions taking place in the soil, such as precipitation/dissolution and cation exchange, are discussed. One of the important conclusions from the work is that desalinated water dissolves carbonates relatively fast in the unsaturated zone and shallow groundwater of the infiltration site. This process which increases significantly the water's alkalinity also enriches the water with magnesium which is highly deficient in desalinated seawater and is an unsolved concern. Using the Menashe MAR system for remineralization of the infiltrated desalinated water looks attractive both economically and environmentally.

Deliverable 14.1 "Recharge water constituents: Data base on compounds in different water sources used for MAR from literature and from the MARSOL demo sites"

Authors: Christine Kübeck (IWW), Axel Bergmann (IWW)

This study is focused on the compilation of a database listing the chemical inventories of potential water sources with emphasize on synthetic micropollutants such as pharmaceuticals, industrial compounds, personal care products, and pesticides. A literature review has been conducted gathering information about occurrence and measured environmental concentration of specific micropollutants in non-system water potentially used for MAR schemes in countries of the Mediterranean region. Particular attention has been paid to pharmaceuticals as active substances of high ecological relevance. In addition, water sources used for groundwater recharge at MARSOL demonstration sites have been analysed and data gathered.

The study clearly shows that a vast amount of synthetic compounds are used for domestic and industrial purpose; pharmaceuticals alone comprise several thousand of active compounds and the numbers are continuously increasing. Thus, an important component assessing potential risks associated with MAR schemes is the determination of overall chemical inventory as well as specific occurrence of compounds and compound mixtures in different water sources. Considerable contamination with respect to pharmaceuticals and industrial agents as well as food additives can be found in wastewater treatment plant effluents and as a consequence, also in receiving surface waters. Based on this, appropriate polishing goals considering site specific factors of applied MAR schemes should be developed and applied.

Deliverable 17.1 "Legislative Framework Review and Analysis"

Authors: Francesca Capone (SSSA), Matteo E. Bonfanti (SSSA)

The report analyses the normative framework which governs the creation and functioning of MAR schemes in Europe and in the extra EU countries where this system is widely used, i.e. Australia and the USA. The authors have collected data concerning the national legal frameworks of nine EU countries that adopt MAR schemes through a questionnaire which has been submitted to a number of national experts. Based on the two EU Directives relevant for MAR Schemes, i.e. the Water Framework Directive 2000/60/EC and the Groundwater Directive 2006/118/EC, the report aims at providing answers to key questions such as: who can establish a MAR system, where, for which purposes and under which conditions? Which kind of monitoring and planning tools have to be used? To further, and better, steer the EU Member States' efforts to regulate MAR schemes, the authors recommend measures such as guidelines and declarations as opposed to new legislation, and refer to the Australian Guidelines as an example of a successful attempt to enhance the regulation of MAR schemes through soft law instruments.

WORKSHOP 5: 'Legal Issues, Policy and Governance of MAR Activities'

MARSOL Training Workshop, Malta, October 2015

The fifth MARSOL workshop was held during the 21-23 October 2015 in Malta. The overall objective of the MARSOL "Legal Issues, Policy and Governance of MAR Activities" Workshop, was to contribute to the definition of a regulatory system that supports the application of MAR schemes on an EU wide scale. An initial draft regulatory system developed by SEWCU was presented during the workshop for discussion between the project partners. This discussion sought the active contribution through presentations of all the MARSOL partners involved in the technical assessment and development of MAR schemes, namely: (i) the MARSOL horizontal work packages – who are to contribute to the development of the 'regulatory tests' under the proposed regulatory scheme; and (ii) the MARSOL vertical work packages – who are to test the application of the regulatory scheme on the pilot MAR case studies under the project. The conclusions of this workshop are being used to refine the Draft Regulatory Scheme to ensure that it contributes to offering a high level of protection to the water environment, whilst enabling the safe application of MAR technologies.

This Demo Site for the implementation of a seawater intrusion barrier is located in the Southern region of Malta. This location presents the typical hydrogeological characteristics of a coastal 'floating-lens' aquifer system, in direct lateral and vertical contact with seawater.

The selection of this site was guided by two further considerations, namely:

1. the groundwater body in this area is considerably degraded, particularly in terms of salinity; and
2. the site is located close to the main wastewater treatment plant of the island, and thus to a reliable source of treated sewage effluent.

The Malta South demonstration project involves the use of a line of coastal boreholes through which treated sewage effluents (which actually is of a better quality than the groundwater in the coastal fringe of the aquifer) will be directly discharged to the saturated zone. It is envisaged that the production of treated wastewater at the Malta South wastewater treatment plant will exceed the demand of the agricultural sector in the region, making it available for aquifer management purposes. The quality of the recharging water will be ensured through the treatment regime (tertiary treatment and/or further polishing) applied in the wastewater treatment plant.

▼ **Demo Site 8 South Malta Coastal Aquifer, Malta**

▲ **Members of the MARSOL consortium at the Demo Site**

WORKSHOP 6: 'Investigation and Monitoring Techniques'

▲ Workshop participants following presentation delivered by Prof. Dr. Christoph Schüth (TUDa)

MARSOL Training Workshop, Lavrion, Greece, March 2016

The sixth MARSOL training workshop, titled "Investigation and Monitoring Techniques in MAR" took place on 16-18 March 2016 in Lavrion, Greece. The workshop covered aspects of environmental monitoring technologies, focusing on the monitoring of hydrologic and water quality parameters that are crucial for Managed Aquifer Recharge facilities and featured in-door sessions as well as participation in active field work and site visits. The event had 65 registered attendees from a record number of countries (there have been more than 20 countries represented from five continents) plus a floating attendance for specific sessions.

In total 21 presentations were given from project partners who lead the eight demo sites involved as well as from external experts and various Greek and German institutions related to the branches of metallurgy, hydrogeology, geophysics, ICT, instrumentation, etc. The workshop included expositions of the efficiency of various monitoring technologies such as direct push, wireless sensors, time and frequency domain technologies, management parameters based on ICT, smart sensors, etc. MARSOL partner UFZ also brought from Germany a full investigation and drilling truck with different systems and equipments, to continue research efforts at the site and at the same time demonstrate the methodologies to the workshop participants.

▲ Workshop participants following demonstration of wireless transmission monitoring systems at the MARSOL demonstration site.

Demo Site 1 Lavrion Technological & Cultural Park, Lavrion, Greece

Lavrion Technological & Cultural Park (LTCP) of the National Technical University of Athens is located at the coastal area of Lavrion (Attica), within the wider area of Athens. The case study combines all typical Mediterranean water problems and hydrogeological settings (i.e. seawater intrusion, water scarcity, karst aquifers, extensive irrigation etc.) and MAR application is envisaged to combat all those. The pilot site involves the employment of infiltration basins at experimental scale, which are using water of impaired quality as a recharge source, hence acting as a Soil Aquifer Treatment (SAT) system. The LTCP site is used as a reference experimental site to develop, adapt, integrate and demonstrate new technological developments that can provide:

- High resolution monitoring of MAR related hydrologic processes
- Subsurface investigation and characterization through the application of advanced in situ technologies
- Reliable acquisition and transfer of environmental data
- A web-based portal application for reliable data storage and management

WORKSHOP 7: 'Water to Market: Financial and Economic Analysis of MAR Solutions'

MARSOL Training Workshop, Venice, Italy, June 2016

The seventh MARSOL training workshop took place in Venice, Italy on the 6th June 2016. The workshop featured presentations and discussions around MAR-related topics such as economical and financial issues and possible market potential. Based on a survey of MARSOL's demonstration sites, their financial profitability and sustainability was analysed, and an assessment of hypothetical larger scale projects was attempted. The Workshop included a demo sites session during which the contribution of the demo sites to financial and economic analysis of MAR solutions was discussed.

▲ Members of the MARSOL Consortium following the workshop

A field trip to the Rio Brenta demonstration sites was organised, and the monitoring system, modelling activities, and respective results were presented. The trip included a visit to the Schiavon demo site and another to the Loria demo site. The topic tackled by demo site 5 is rural water management, specifically the problem of water scarcity and conflicts with other water users in the irrigation season.

The demo site uses a Forested Infiltration Area (FIA) for Aquifer Storage and Recovery (ASR). The FIA uses furrow irrigation for ensuring infiltration into the aquifer; an ecological crop cultivated on the overland area maximizes the infiltration rate and provides ecological services. A system of furrows is fed by drainage channels connected to the irrigation ditch of the local irrigation network. The system operates continuously during the non-irrigation period during the winter months ensuring that ecological flows of rivers are maintained, and on an intermittent basis during the irrigation period in the summer months.

▲ DEMO Site 5 River Brenta Catchment, Vicenza, Italy

The land that is forested to facilitate the infiltration of surface water into the ground can also be managed for a variety of other purposes, such as the production of woody biomass for renewable energy. FIAs can provide interesting opportunities for farmers to supplement their incomes hence the derived economic benefits would make it viable and sustainable.

The demo site intends to show the impact of Infiltration Forested Areas on: Aquifer Storage and Recovery; Ecological monitoring; Ecological Services; and Cost-benefit analysis of MAR versus conventional solutions for water supply.

COWM 2016 - Citizen Observatories for Water Management

MARSOL consortium members also participated in the COWM 2016 - Citizen Observatories for Water Management (www.conwater2016.eu)

During COWM 2016 a special session was organized where technical and administrative aspects of Water Solutions to Market were debated. This session addressed the Eastern Alps Hydrographic District stakeholders (public administrations, land reclamation consortia, farmers, local and national politicians). Among the invited participants to the special event were: ANBI (National Association of Consortia for Management and Protection of Land and Irrigation Water), the Italian Minister of Environment, the Italian Minister of Agriculture, Irrigation and Reclamation Consortia and local mayors.

Apart from the event specifically related to the MARSOL activities, many points of connection with MARSOL topics were identified (the potential of Citizen Science in the fields of environmental monitoring (drought, pollution events, etc.).

The Conference topics included Catchment monitoring and management, Methods and technologies for Citizen Observatories and Citizens' involvement in decision making: organizational, legal and societal aspects.

▲ Members of the MARSOL Consortium

MARtoMARket AG: EIP CONFERENCE 2016

EIP Conference, Leeuwarden, The Netherlands, February 2016

Boosting Managed Aquifer Recharge in Europe - side meeting

As a partner of the European EIP Water Action Group "MAR Solutions – Managed Aquifer Recharge Strategies and Actions (AG128)" – www.eip-water.eu, members of the MARSOL consortium participated in this year's EIP Conference and led the **'Boosting Managed Aquifer Recharge in Europe - side meeting'**

This side meeting was held on 9 February and aimed to present and discuss the best way for training researchers, industry/SMEs, and end users on Managed Aquifer Recharge (MAR) as well as on new developments in this field; furthermore, the organisers aimed to foster the MAR project partners' knowledge and to ensure that MAR project's RTD and Demo results effectively reach the end-users.

About 20 participants registered for the meeting and were exposed to ten presentations from seven EU Member-states, sponsored by several FP7, H2020 and national MAR projects. The presenters highlighted that during 2015 six out of eight FP7 MARSOL project demonstration sites had been either newly developed or upgraded.

The MARtoMARket Action Group stressed the relevance of MAR technologies as part of the solution towards a better adaptation to climate change, reinforcing the green circular economy not only in Europe, but also in the Mediterranean and worldwide.

http://www.eip-water.eu/MAR_Solutions

EIP Water Action Group
Pooling resources – Innovating water

M.A.R. TO MAR-k€t

Upcoming Events

The last few months of MARSOL will see a number of events taking place and the completion of this project, which has had many successes along the way.

MARSOL Consortium Final Meeting

Leipzig, Germany, Mid-October 2016

More information about this meeting will be available shortly.

Advanced Study Course (ASC) for Academics and Young Scientists

"Managed Aquifer Recharge: Water Quality and Reactive Modeling"

Barcelona, Spain, 7 - 9 November 2016

During this course, which will be delivered by MARSOL partners and international experts, the knowledge and expertise available in MARSOL will be utilised for training of academics and young scientists on aspects of water quality of recharge water sources and on state-of-the-art reactive modeling methods. For further information on program, venue, and registration procedure please check the MARSOL website under "Events".

MAR SOL

MANAGED AQUIFER RECHARGE SOLUTIONS

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