MARSOL

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

Training Documentation

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Contents

1 Goal and Scope

A long-term impact of the MARSOL project can only be assured if effective information, dissemination, exchange of ideas, and training of end users on the project's expertise and results is conducted. Specifically training activities aim at bridging the gap between the technology developers and researchers and the actual users of the technologies. Project end users need to be fully aware about the findings of the project to ensure that the results will ripe into future sustainable applications of MAR. Therefore the success of the project relies substantially on the planned training activities.

Building on the opportunities the project's demonstration sites offer, dissemination and training activities were based at the eight demonstration sites of the project. A workshop plan was set up building on the eight demo sites work packages as well as the "horizontal" work packages of the project addressing core issues such as Investigation and Monitoring, Modelling, Technical Solutions, Water Quality, Financial and Economic Analysis of MAR, Technology Assessment and Risk, and Legal Issues, Policy and Governance.

Each of the events aimed at both, facilitating discussions, exchange of ideas and training among the MARSOL partners and their staff but also experts from other MAR-related projects, and informing and/or training interested stakeholders such as, for instance, farmers and irrigation communities, industry, water and environment authorities, politicians, and even other technicians and researchers in the water sector, and graduate students.

For the end of the project, as one of the final activities, an Advanced Study Course (ASC) for Academics and Young Scientists on innovative MAR approaches was planned. Since independently from the MARSOL project, and not known at the time of the writing of the MARSOL proposal, another project on sustainable water management (INOWAS at TU Dresden) set up an international summer school on Managed Aquifer Recharge, to take place only 2 months before the planned dates of our Advanced Study Course, we planned to shift the scope of our planned event from covering MAR as a whole to focussing on a selected aspect of special interest and treating this specific subject (water quality aspects and reactive transport modelling) in-depth.

The events were typically organized as having an in-door workshop component with presentations and discussions, and a field trip component with field trips and demonstration site visits, to be organized by the local – demonstration site related – project partners. Fig. 1 gives an overview of the workshop schedule.

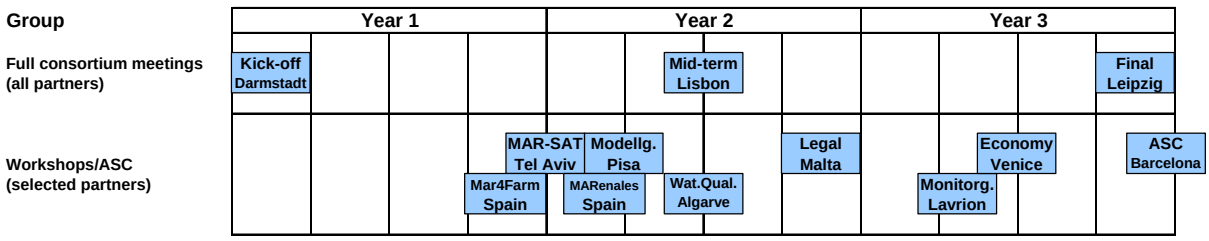

Fig. 1: Overview of the realized workshop schedule.

2 MAR4FARM Workshop, Castile and Leon, Spain, 2014

2.1. Basic data

Event name:

Managed Aquifer Recharge in Santiuste Basin Aquifer - MAR4FARM Workshop

and

Managed Aquifer Recharge in Carracillo District Aquifer - MAR4FARM Workshop

Dates:

29 - 30 October 2014

Location:

Santiuste de San Juan Bautista and Gomezserracín, Segovia province, Castile and Leon, Spain.

Partner(s) Organising:

Empresa de Transformacion Agraria, S.A. (Tragsa)

Tecnologias y Servicios Agrarios, S.A. (Tragsatac)

2.2. Audience

Around 30 participants attended the workshop in Santiuste and 60 in Gomezserracín. An important target audience of the workshops were local irrigation communities boards, of which some are supporters of the MARSOL project and the MAR-TO-MARK€T EIP AG 128. The workshop language was Spanish.

2.3. Program

29 October, Exmo. Ayto. de Santiuste de San Juan Bautista (Segovia)

- Welcome - D. Octavio Esteban Fernández (President of the Cubeta de Santiuste... irrigation community)
- Enhanced recharge general aspects (before artificial recharge) - João Paulo Lobo Ferreira (LNEC, Portugal)
- The activity seen from the Duero river basin and the RBMP. Description of previous studies - D. Víctor del Barrio Beato (Duero Basin Confederation)
- Irrigation with reclaimed water. The Alcazarén experience - D. José Luis Sevilla Portillo (Junta de Castilla y León)
- Aquifer functioning and behaviour - Enrique Fernández Escalante (Tragsa, Spain)
- Building Works description - D. Roberto Fernández García (Tragsa, Spain)

- Environmental aspects of Managed Aquifer Recharge in Santiuste basin - Dr. Jon San Sebastián Sauto (Tragsatec, Spain)
- Water management techniques at user scale. Recommendations. Presentation of the Ebook - Enrique Fernández Escalante (Tragsa, Spain)
- Energy efficiency and use of alternative energy systems for irrigation. Practical techniques - José Manuel Omaña Álvarez (AIMCRA-Plan 2020)
- Open debate - Rapporteur: D. Luis Sayalero (Technician of the Santiuste... irrigation community)
- Closing - Sr. D. Juan Martín Gómez (Mayor of Santiuste de San Juan Bautista)

30 October, Centro cultural "Las Fuentecillas", C/Alta, nº 21-23. Gomezserracín (Segovia)

- Welcome - D. Enrique Herranz (President of the Carracillo Irrigation Community)
- Enhanced recharge general aspects (before artificial recharge) - Dr. Ing. João Paulo Lobo Ferreira (LNEC, Portugal)
- The activity seen from the Duero river basin and the RBMP - D. Víctor del Barrio Beato (Duero Basin Confederation)
- Description of previous studies. Phases 1 & 2 - D. Juan Martínez Rubio (Tragsatec, Spain)
- Building Works description - D. Roberto Fernández García (Tragsa, Spain)
- Environmental impact, specially on forest masses - Jon San Sebastián Sauto (Tragsatec, Spain)
- Water management techniques at user scale. Recommendations - Enrique Fernández Escalante (Tragsa, Spain)
- Modeling as a tool to study the evolution in quality and quantity of the water in the aquifer - Xavier Sánchez Vila (UPC, Spain)
- Reclaimed water for MAR and irrigation. The Alcazarén SAT-MAR experience - D. José Luis Sevilla Portillo (Junta de Castilla y León)
- Energy efficiency and use of alternative energy systems for irrigation. Practical techniques - José Manuel Omaña Álvarez (AIMCRA-Plan 2020)
- Open debate - Rapporteur: Carracillo I.C. Secretariat
- Closing - Sra. Dª. Laura del Río Arranz (Mayor of Gomezserracín)

2.4. Summary and conclusions

Since 2002, when MAR activities began in this sector of the Arenales aquifer, considered a building work for the general interest of the nation, recharge activities have been accomplished by means of the irrigation community, counting on the support, when required, from those technicians involved in the studies and building works.

After a decade, many groundwater users and farmers ignore a great part of this activity. Within the MARSOL project context, and with the help provided by Santiuste and Carracillo

irrigation communities, two consecutive workshops, called MAR4FARM, have been organized by Tragsa, exposing these experiences in the main Arenales aquifer MAR areas.

The workshop was held on two consecutive days at Santiuste de San Juan Bautista and Gomezserracín (Segovia), respectively. Sessions were especially aimed to farmers and the general population in these rural areas, so, technical language was eluded in presentations. The irrigation communities collaborated actively in its organization and dissemination.

The experience has been very rewarding: in addition to knowledge spreading over a rural zone where some attendees expressed their feeling of being "forgotten", the range of dissemination of research project results has been expanded to the 'general public', when this sort of activity usually tends to be focus on scientists, technicians and professionals. With this the project started a new stage of dissemination with the goal of expanding the range of target groups receiving first-hand information on technological solutions. It was planned to increase this activity along the MARSOL project.

About the workshop itself

- The workshop has been addressed with a broad approach, from a general and global perspective, to the specific area, being the first part less interesting for the attendance than the second one. In future sessions, it would be desirable to reduce preliminary and general aspects, strengthening on unambiguous concepts.
- The stakeholders seemed to be more interested in the current situation and, specially, in the future evolution of the project and the area, and how they will be affected as individuals. They paid little attention to past events.
- Speakers must make a greater effort to avoid technical language.
- The purpose of the workshop has been successfully achieved, as knowledge has been brought to groundwater users related to these MAR activities, who welcomed the workshop with satisfaction and gratitude. That is why this kind of workshops should be periodically repeated.

Remarkable/ innovative aspects from the presentations

- It is important to highlight the need of considering the management and maintenance of MAR facilities as one of the most important aspects to ensure appropriate operation and preservation, as well as to improve its visibility.
- MAR is essential to ensure a good irrigation water quality (less nitrates and arsenic) and quantity to be applied by farmers. The extraction is more or less equal to the infiltration rate: approx. 62 hm^3/year, according to hydrogeologist Mr. Victor del Barrio. This situation is expected to get worse in the future according to climate change previsions. The rise of the water table level for the irrigation period has a direct impact in a lower energy consumption of irrigation water pumping from wells, and therefore, in a reduction in the electricity or fuel bill.

- Good MAR water quality ensuring for irrigation purposes brings an added value for farmers in the shape of better quality crops with higher yields, further higher incomes and an easier marketing.
- In short, higher crop yields and lower costs (by reducing the electricity bill), could impact in a more optimal economic return to farmers who consume groundwater from MAR devices.
- Assuring sustainability of irrigation will allow holding population in the area.
- MAR techniques are also interesting for reducing floods by storing water excess.

Specific conclusions and recommendations

- In the main sectors of Los Arenales aquifer, the irrigated surface has doubled in 10 years.
- It might be important to advise users and the population in general, related to future water management: “Do not close a well, reuse it”. Those old wells that have been abandoned due to diverse reasons might be included in the MAR system. It can be accomplished by connecting the old excavation to ponds or channels by means of a single pipe (passive scheme with no energy consumption), and refill it with coarse gravel. This sort of actions is affordable and increases the groundwater storage. Some particular experiences in Santiuste Basin are improving the effectiveness of MAR devices.
- Another key element within this framework might be: “Association as a fortress”. Communities operate MAR facilities more effectively than individuals.
- Irrigation communities must be part, and even the main contributor to the operation and conservation of MAR devices. It is important to count on expert advice, too.
- Groundwater users and practitioners should monitor water authorities, due to changes in the MAR permits, changes in allowances depending on environmental conditions, potential calls to obtain some support… mainly those related to changes in environmental conditions.
- The public-private partnership (PPP) schemes must be approached, as well as the schemes based on innovation and multi-level governance applicable for MAR zones.
- It is endorsed to include in the dissemination material, such as map panels or brochures informing groundwater users, data about estimation of the amount of money saved by means of MAR in irrigation since the beginning of the activities (electricity, pumping cost, etc., and the additional incomes after converting a rain-fed area into an irrigation area).
- It is also imperative to disseminate the results and practical criteria obtained at other demonstration sites and international experiences.
- The slogan based on the info exposed in INPRESS reports: “MAR is a driving force” must be defended permanently.

General conclusions

- MAR technique is developing a strong practical potential that should be broaden.
- It is important to walk steps towards the general awareness that induced recharge increases the groundwater quantity as well as the quality. The concept of MAR as a "driving force" must be remarked permanently.

- The current state of the MAR facilities must be adapted to new MARSOL and MAR-TO-MARK€T objectives (demo sites).
- It is important to perform MAR activities without interfering in the farmers' work, so as to facilitate their cooperation.
- Blue print datasets have huge differences among Spanish regions, what is due to, in a certain measure, their industrial activity. So, industries involved in MAR-TO-MARK€T EIP AG should be carefully chosen.
- The "green water" is becoming more and more important in the Spanish economic activity, and its connection to MAR is becoming more important in order to avoid environmental negative impacts.
- Lower energy consumption due to water table raise, and the consequent reduction of pumping cost, is, beyond any doubt, profitable for farmers, due to the lower electricity bill.
- SAT-MAR activities, understood as irrigation with reclaimed water, brings a good opportunity for future rural development, but requires a very careful and expert management, as well as permanent improvements, in order to avoid negative experiences with a direct influence in the public perception.
- The dissemination of R&D advances to users is a key element for "future MAR". It is important the cooperation of the receivers. This can be achieved by means of increasing their interest in the project. Providing advice on their economical savings plays an important role in this issue.
- It is necessary to maintain and increase the channels of communication for the exchange of international experiences, with the aim of sharing criteria, results, experiences... It is convenient to transfer both, the negative and the positive experiences.
  The water balance used by the 9 industry branches considered by MtoM AG must be solved when possible for different countries. It is important to point out the most relevant aspects for each:

  1. Agro-industry
  2. Water supply industry
  3. Waste water treatment plants
  4. Desalinations agents
  5. Bottled companies
  6. Golf courses
  7. Public administration branches
  8. Balnearies & spas (sallus per aquam)
  9. Hotels and tourist facilities (market uptake)

Fig. 2: MAR4FARM workshop held at the Santiuste and Gomezserracín city councils, Segovia province, Spain.

2.5. Selected dissemination activities

iAGUA channel, news on water for Spanish speaking countries with over 4,000 recipients:
http://www.iagua.es/eventos/recarga-gestionada-acuifero-carracillo

Spanish Water Technology Platform (Plataforma Tecnológica Española del Agua - PTEA):
http://www.plataformaagua.org/
News and links published in their monthly bulletin nº 17, 14 October 2014.

EIP MAR to MAR-K€T (AG 128):
http://www.eip-water.eu/mar4farm-workshops-mar-general-population-rural-areas-experimental-dissemination-activity-mtom

DINA-MAR (IAH MAR Commission sister website):
http://www.dina-mar.es/post/2014/11/17/MAR4FARM-PRESENTACIONES-PRESENTATIONS-AVAILABLE-FREELY-ON-THE-INTERNET.aspx

LinkedIn:
https://www.linkedin.com/groups/4690290/4690290-5924821962714017792

MARSOL website:
http://www.marsol.eu/70-0-Past-Events.html

3 MAR-SAT Workshop, Tel Aviv, Israel, 2014

3.1. Basic data

Event name:

MAR-SAT Expert Forum Workshop and Field Trip

Dates:

3 - 4 December 2014

Location:

Tel Aviv, Israel

Partner(s) Organising:

Mekorot Water Company Israel

3.2. Audience

The workshop was attended by 26 registered participants. As a representative of MARSOL's External Advisory Board (EAP) the consortium was pleased to welcome Dr. Peter Dillon from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, to the workshop.

3.3. Activities and Program

The program started with a day of site presentations and site visits at the Shafdan Wastewater Treatment Plant and the Shafdan conventional SAT infiltration basins:

- Presentation of the Shafdan Project - Tel Aviv Region wastewater collection and treatment, and the conventional SAT technology - Avi Aharoni (Mekorot)
- Secondary effluents pilot treated by AOP-Short SAT - Anat Lakretz (Mekorot)
- Secondary effluents pilot treated by UF-RO - Anat Lakretz (Mekorot)
- Secondary effluents pilot treated by SAT. Simulation by sand columns - Omer Minis, Ido Negev (Mekorot)
- Open discussion: "Can upgraded conventional SAT be relevant for Europe?"
- Visit of WWTP

On day 2 and 3, presentations were given from EU FP7 project partners and other researchers about all kind of aspects of MAR-SAT. During the welcome session a video message from the EU office in Brussels with Rossella Riggio and Robert Schroder was shown focussing on the future water policy and water funding strategy of the EU. Outline of the presentations program:

- Welcome statement - Avraham Ben Yosef (VP for Engineering and Technology, Mekorot)

- Welcome statement - Ayala Karniol (Director Health, KBBE, Environment, Energy, ISERD The Israel-Europe R&D Directorate)
- Welcome statement - Yossi Yaacobi (WaTech Innovation Center in Mekorot)
- Welcome statement (by video message) - Rossella Riggio, Robert Schroder (European Commission, DG RTD, Unit I2 Eco-Innovation)
- MARSOL project presentation - Christoph Schüth (TU Darmstadt, Germany)
- SAPH-PANI and DEMEAU. Highlights from the projects - Christoph Sprenger (Kompetenz-zentrum Wasser, Berlin, Germany)
- DEMOWARE project presentation - Ulf Miehe (Kompetenzzentrum Wasser, Berlin, Germany)
- IAH Commission on Managing Aquifer Recharge and its activities - Peter Dillon (CSIRO, Australia)
- MAR to Market AG. Relationship with the European Commission action group (AG 128) - Enrique Fernandez Escalante (Tragsa, Spain)
- MAR activities in Mekorot. Design of new injection wells for injecting surplus desalinated water into the aquifer - Yossi Guttman (Mekorot, Israel)
- BMBF-MOST. Ozonation of treated wastewater followed by groundwater recharge - Martin Jekel, Uwe Huebner (TU Berlin, Germany)
- Urban storm water biofiltration and recharge to groundwater - Yaron Zinger (Monash University, Australia)
- MAR-SAT. The Australian experience - Peter Dillon (CSIRO, Australia)
- MAR to MARket AG 128. Examples of MAR based on alternative sources of water - João Paulo Lobo Ferreira (LNEC, Portugal)
- Dunes of St. Andr. Recent experiences with infiltration of reclaimed secondary effluent - Emmanuel Van Houtte (IWVA, Belgium)
- SAT-MAR pilot facility in Arenales aquifer (Spain). Clogging and water quality evaluation - Enrique Fernandez Escalante (Tragsa, Spain)
- EU project RECLAIM. Results related to MAR-SAT - Thomas Wintgens (FHNW, Switzerland)
- El Porto Del Selva Northern Spain: A demonstration study on MAR for wastewater reuse - Ulf Miehe (Kompetenzzentrum Wasser, Berlin, Germany)
- Reduction of manganese dissolution and micro-pollutants by Enhanced Short SAT - Avi Aharoni, Haim Cikurel (Mekorot and Tel Aviv University, Israel)

After the presentations a round table and discussion for the foundation of a MAR-SAT Experts Forum took place.

3.4. Summary and conclusions

MARSOL partners met with colleagues from the EU FP7 projects DEMEAU and DEMOWARE and other researchers and professionals working in the field of MAR-SAT to exchange information on MAR-SAT topics and to create a MAR-SAT expert forum. The 2 day meeting showed a lot of synergies. The workshop provided an excellent forum for networking and laying the ground for further new projects, e.g. in Horizon 2020.

It was very valuable to receive an overview of the different projects taking place in the EU and outside of the EU. It was emphasized to join forces to be able to efficiently contribute to EU policies, governance, guidelines, standards, policy recommendations etc.

A 34-pages field trip reader was produced and distributed among all participants.

At the end of the workshop, a round-table discussion took place. First, the MAR-SAT workshop presentations were briefly summarized and reviewed. It was pointed out that the different MAR-SAT working groups show a lot of synergies. The workshop provided an excellent forum for laying the ground for further new projects, e.g. in Horizon 2020. It was very valuable to receive an overview of the different projects taking place in the EU and outside of the EU. It was suggested to send a message to the EU that it was a very useful event. It was emphasized that we should aggregate forces to be able to efficiently contribute to EU policies, governance, guidelines, standards, policy recommendations etc. In addition, knowledge gaps have to be addressed in the future. Stakeholders should be taken into account. Further activities were discussed, as well as how MAR-SAT could be better represented in the future. It was suggested that EIP WATER will be used to further promote MAR-SAT and as a platform to connect stakeholders. It would be welcome if Mekorot would play an active role in this activity.

Fig. 3: Participants of the MAR-SAT workshop in Tel Aviv.

3.5. Selected dissemination activities

DINA-MAR (IAH MAR Commission sister website):
http://www.dina-mar.es/post/2014/12/10/DINA-MAR-en-el-SAT-MAR-Experts-Forum-Tel-Aviv-4-de-diciembre-de-2014.aspx

LinkedIn:
https://www.linkedin.com/groups/7453856/7453856-5942373707912609794

Facebook:
https://www.facebook.com/marsolproject/posts/773793639372380

MARSOL website:
http://www.marsol.eu/70-0-Past-Events.html

4 MARenales Workshop Spain, 2015

4.1. Basic data

Event name:

MARSOL Workshop on Technical Solutions for Managed Aquifer Recharge

MARenales - Soluciones tecnológicas para la recarga gestionada de acuíferos

Dates:

9 - 11 March 2015

Location:

Los Arenales aquifer region, Segovia Province, Castile and Leon, Spain. Starting point on first day in Madrid.

Partner(s) Organising:

Empresa de Transformacion Agraria, S.A. (Tragsa)

Tecnologias y Servicios Agrarios, S.A. (Tragsatac)

4.2. Audience

The closed-doors session was directed at invited technicians and experts. The closed-door session and the field trip were attended by 29 participants.

The opened-door session was directed to technicians, practitioners, public authorities, farmers, local irrigation communities' boards, as well as students. The population in general will be invited as well. The session had 50 attendants from seven European countries, plus Korea and Israel, including technicians from the regional river basin authorities and from the regional government as well as invited guests from other, thematically related European projects. Spanish was the official language of the workshop, with presentation slides in English.

As a representative of MARSOL's External Advisory Board (EAP) the consortium was pleased to welcome Dr. Yongcheol Kim from the Korea Institute of Geoscience and Mineral Resources (KIGAM), to the workshop.

4.3. Activities and Program

Overview: the workshop included 3 days of indoor and outdoor activities:

9.03.2015: Closed-doors training in Coca village (Segovia, Spain)

10.03.2015: Visit to Santiuste basin and Alcazarén MAR and SAT-MAR facilities

11.03.2015: Visit to Carracillo council facilities. Open-doors training presentations.

9 March, Coca village, Segovia; Internal workshop with external experts; English as official language

- Effective MAR performance in water-curtain insulated greenhouse complex: technical solutions and problems unsolved - Yongcheol Kim (KIGAM, Korea)
- Los Arenales aquifer: description and Managed Aquifer Recharge (MAR) facilities. Explanation of the Los Arenales aquifer, demo site description and hydrogeological functioning - Enrique Fernández Escalante (Tragsa, Spain)
- Technical solutions for MAR facilities construction. Detailed description for building works, design and materials employed - Roberto Fernández García & Francisco de Borja González Herrarte (Tragsa, Spain)
- An Environmental approach to MAR technical solutions and benchmarking - Jon San Sebastián Sauto (Tragsatec, Spain)
- MARSOL Portugal: Constructions and site investigation techniques - Tiago Carvalho (TARH, Portugal)
- Demonstrating managed aquifer recharge as a solution for climate change adaptation: experiences from LNEC Portugal - Teresa Leitão & Manuel Oliveira (LNEC, Portugal)
- Managing technical solutions for MAR in Arenales aquifer. Practical advises - Enrique Fernández Escalante & Roberto Fernández García (Tragsa, Spain)
- Demoware invited presentation - Elisenda Taberna (Veolia, Spain)
- Novel technical method to monitor temporal change of FW-SW interface for a MAR site in coastal area - Yongcheol Kim (KIGAM, Korea)
- Premiere of MARenales short film

10 March, field visits Santiuste basin and Alcazarén SAT-MAR

Visit to Santiuste basin facilities (MAR dam, MARSOL ZNS stations, triplet: waste water treatment plant-biofilter-artificial wetlands, and the Northern area, Wetland recovered by means of MAR operations, MARSOL new experimental infiltration pond. SAT-MAR experience in Alcazarén and visit to the WWTP in Pedrajas. Visit to environmental artificial wetlands, MAR dam to raise the groundwater level in the aquifer in Carracillo, visit to MARSOL piezostar in Gomezserracín.

11 March, Gomezserracín, Segovia. Open-door training workshop. Spanish as official language with presentation slides in English

- MAR and water footprint / Recarga gestionada de acuíferos (MAR) y huella hídrica - Elvira del Pozo Campos (Tragsatec, Spain)
- Methodology for probabilistic risk evaluation linked to MAR activities based on fault tree analysis / Metodología para la evaluación de riesgos ligados a actividades de recarga gestionada de los acuíferos - Xavier Sánchez-Vila (UPC, Spain)
- Practical technical solutions for Managed Aquifer Recharge facilities / Soluciones tecnológicas prácticas para dispositivos de recarga gestionada - Enrique Fernández Escalante (Tragsa, Spain)

- Urban rain water harvesting and infiltration. Architectonical designs and solutions / MAR y cultivo de agua en la edificación. Diseños y soluciones arquitectónicas - D. Ignacio Prieto Leache (Tragsatec, Spain)
- Low impact MAR activities and benchmarking / El bajo impacto en las actividades asociadas a MAR y "benchmarking" - Jon San Sebastián Sauto (Tragsatec, Spain)
- MAR, energy efficiency and use of alternative energy systems for irrigation. Technical solutions / MAR, eficiencia energética y energías alternativas en el regadío. Soluciones tecnológicas - D. Francisco de Borja González Herrarte (Tragsa, Spain)
- ICTs solutions for MAR activities / Soluciones TICs para las actividades de Recarga Gestionada de Acuíferos (MAR) - María Eugenia García de Garayo y Millán (Tragsa-Wire AG, Spain)
- Technical solutions for MAR experiences in Spain. State of the art and future panorama / Soluciones técnicas de las experiencias en MAR en España. Perspectiva future - José Antonio de la Orden Gómez (Spanish Geological Survey, IGME)
- Premiere of the short film "MAR Technical solutions in Los Arenales aquifer"/"Soluciones tecnológicas en MAR en el acuífero de los Arenales"

4.4. Summary and conclusions

The main objectives for this specific workshop were to present and discuss the different technical solutions of MAR applied by the MARSOL partners' expertise regarding each demonstration site, and studying their applicability to other equivalent environments. In particular the workshop focussed on the following points:

- Successful construction criteria (materials, shapes, specific designs…).
- Successful management criteria, mentioning the 'must' as well as the 'mustn't'.
- Criteria for cleaning and maintenance of existing structures enhancing the infiltration capacity and the life-span of the structures.
- Other criteria such as benchmarking, indicators, and dissemination procedures.

Conclusions from the closed-doors session

- It is important to strengthen the cooperation with other EC-supported projects. In the next MARSOL activities, participants from DESSIN, DEMOWARE, etc. and experts of recognized prestige in the field of water management and MAR will be invited.
- The training workshops must include a balance of members from the industry and from the academia, in order to expose the scientific background as well as the practical application of the outcomes.
- The technicians implicated in the irrigation community operations should receive the results of the project, as an agent to provide some help in the dissemination for farmers and the population in the rural area in general.
- The presentation of successful cases of cooperation among stakeholders, scientists and regional authorities is important in order to provide some inputs and possible changes related to the current regulations.

- The cooperation with local agents is imperative in order to involve the industry more and more in the water management techniques.

Conclusions from the opened-doors session

Specific conclusions and recommendations:

- The president of the local irrigation community commented that there are more MAR experiences in Spain than he expected, remarking his good impression. He even mentioned people are not aware of the intensive use of MAR technique for water management related to irrigation in his closest circle.
- Farmers in the area who attended the training workshop brought up the importance of how convenient the support of these agents has been, bringing the general knowledge into practical advises, either from the public administration or from R&D projects.
- Some attendants expressed their concern for the potential effects of over-pumping and over-recharge, resulting in strong water table oscillations, on the edifications and buildings foundations. Technical solutions on MAR should also consider this potential effect as a problem to be solved in MAR design, operation, and management. Financial liabilities and insurance questions related to the issue where discussed.
- River basin authorities should emit a technical report justifying where the regular un-disturbed water level must stand for each specific area in the aquifer, clarifying possible future responsibilities.
- The assistants shared the feeling that MAR is being profitable for farmers respecting their economic incomes. This profit should be included in the awareness campaigns for some related areas in order to trigger a “contagious” effect on those areas' farmers.
- Some farmers are receiving different benefits from MAR techniques in their area, bringing out some imbalance. Some compensation measure should be established in order to compensate these variances.
- Social problems in relation to MAR deployment are being more serious than the technical challenges. Some specific problems requiring a quick solution in the area are related to the minimum flow rate in the river. To allow the diverting recharge water volumes and the urgent solutions to be performed when MAR devices are stopped no matter the climatic conditions are appropriate to have the facilities working.
- Some farmers wanted to know how the help, if available, is provided by the river authorities for MAR. Competency transference to the irrigation community should imply the respective sanctioning regime too. The main advantage remains in the internal management within the irrigation community, which seems to be better to solve conflicts than any external decision.
- River basin authorities cannot make any decision about energy production or MAR as a water preferential use. The final solution is nowadays in the hands of the Court of Justice.
- The competence problem between energy production and MAR is coming from the origin of the activity. In 1998, when MAR works began, the permission characteristics required a

further development of the legal aspects, documentations and conflict resolution normative.

Remarkable/ innovative aspects from the presentations

- New focus on: water-energy nexus, alternative energy systems for irrigation, risks and hazards, benchmarking calculation, water footprint, technical solutions from the rest of the world, ICT use and implementation of remote sensors and connectivity despite poor or inexistent mobile phone coverage and previous experiences related to R&D projects carried out by the Spanish Geological Survey.
- Most of these activities were not presented in the previous end-users workshop, held in October 2014.
- One of the most relevant presentations for farmers was the one related to the water-energy nexus: how much energy is saved with groundwater elevation and how much the savings might grow installing solar energy facilities.
- It is remarkable mentioning the increasing demand for solar energy facilities applied to irrigation pumping.
- Opinion from water users is essential for technicians. That is why explanatory panels have been located next to the MAR recharge points so feedback is expected.
- It's important to work in low-cost innovation, simple, collaborative aiming global solutions to MAR.
- MAR could be internalized and implemented in so many regular decision processes, as urbanism. The objective is to increase the infiltration in cities and villages for not only filling the aquifer but also to reduce floods and surface run-off.
- MAR has a beneficial social and environmental impact.

General conclusions

- Speakers must make a greater effort to avoid technical language. Also, it would be interesting to ask to the irrigation community which aspects and items they are interested in. In general, talking about solutions to its common problems, as solar energy for decrease its costs in electricity, will be appreciated, as the president of the community expressed.
- It is important to disseminate encouraging examples and successful cases from other experiences around the world among those stakeholders who provide some help in the MAR facilities management.
- Social problems in relation to MAR deployment are becoming more serious than the technical challenges.
- Although there is a certain agreement on MAR as a profitable service for population in the irrigated area, some other people disagree because they don't earn their own living from the agriculture. There is also a rising concern about the potential problems related to geotechnical effects of the terrain, future deferred impacts and even social conflicts.

- The profits overcome the inconveniences as a general rule. That is the main reason why successful schemes should be exported to equivalent areas, promoting a “domino effect”.
- The purpose of the workshop has been successfully achieved, as knowledge has been brought to groundwater users related to these MAR activities again. They also welcomed the training workshop with satisfaction and gratitude. That is why this sort of workshops should be repeated at least once again along MARSOL project.

Fig. 4: Participants of the MARenales workshop during field visit of MAR facilities.

4.5. Selected dissemination activities

iAGUA channel, news on water for Spanish speaking countries with over 4,000 recipients:
http://www.iagua.es/eventos/marenales-training-workshop

Spanish Water Technology Platform (Plataforma Tecnológica Española del Agua - PTEA):
http://www.plataformaagua.org/
News and links published in their monthly bulletin nº 22, 8 April 2015.

IAH MAR Commission (International Association of Hydrogeologist): Announced by email to more than 280 recipients.
- 26/02/2015: Announcement of training workshop
- 17/03/2015: Notice that presentations are available on the Internet

DINA-MAR (IAH MAR Commission sister website):
http://www.dina-mar.es/post/2015/03/16/e2809cMARenalese2809d-CELEBRADO-EL-e2809cTRAINING-WORKSHOPe2809d-DEL-PROYECTO-MARSOL-EN-EL-ACUIFERO-DE-LOS-ARENALES.aspx
http://goo.gl/XTM32b

IAH Spanish Group: Announced by email to more than 280 recipients.
- 30/01/2015: Announcement of training workshop
- 17/03/2015: Notice that presentations are available on the Internet

EIP MAR to MAR-K€T (AG 128):
http://www.eip-water.eu/mar4farm-workshops-mar-general-population-rural-areas-experimental-dissemination-activity-mtom

MARSOL website:
http://www.marsol.eu/70-0-Past-Events.html

KIGAM Korea:
https://www.kigam.re.kr/english/ (password required)

Venue site, city council web site:
http://www.gomezserracin.es/actualidad-municipal/-/asset_publisher/hr5A/content/jornada-tecnica-informativa-la-recarga-gestionada-del-acuifero-del-carracillo?redirect=http%3A%2F%2Fwww.gomezserracin.es%2Factualidad-municipal%3Fp_p_id%3D101_INSTANCE_eL0t%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3Dcolumn-2%26p_p_col_count%3D3&articleId=2320228&groupId=131321

LinkedIn:
https://dz.linkedin.com/groups/MANAGED-AQUIFER-RECHARGE-DINAMAR-4690290

Facebook:
https://www.facebook.com/marsolproject/posts/773794356038975

Twitter:
@plataformaagua
https://twitter.com/fcihs
@HIDROGEOLOGOA/Inguru. infor atariak on Twitter

Google+:
https://m.google.com/app/basic/+FcihsOrg/posts?

Slideshare:
www.slideshare.net/slideshow/embed_code/46361556
http://www.slideshare.net/BoGo_1/5-low-impact-mar-activities-and-benchmarkingjsss

Youtube (MARenales movie):
IAH MAR Commission (DINA-MAR) http://goo.gl/f0EAwZ
Mirror site in Youtube https://youtu.be/Dw22rcEQdiw

5 Modelling Workshop, Pisa, Italy, 2015

5.1. Basic data

Event name:

MARSOL Workshop Modelling of Managed Aquifer Recharge Processes

and

Advantages of using Numerical Modelling in Water Resources Management and Managed Aquifer Recharge Schemes

Dates:

21 - 23 April 2015

Location:

Aula Magna - Scuola Superiore Sant'Anna, Piazza Martiri della Libertà, 33, Pisa, Italy

Partner(s) Organising:

Scuola Superiore Sant'Anna (SSSA)

5.2. Audience

135 participants.

For the MARSOL External Advisory Board (EAP), Dr. Janek Greskowiak from the University of Oldenburg, Germany, participated in the workshop.

5.3. Activities and Program

21.04.2015: Workshop Advantages of using Numerical Modelling in Water Resources Management and Managed Aquifer Recharge Schemes

22.04.2015: Indoor session on modelling focusing on MARSOL partners' presentations, in the afternoon field trip to the Sant'Alessio demo site and the San Niccolò phyto-treatment experimental site

23.04.2015: During the morning indoor continuation of the MARSOL session on modelling and conclusions of the workshop

A 21-pages field trip reader was produced and distributed among all participants.

Advantages of using Numerical Modelling in Water Resources Management and Managed Aquifer Recharge Schemes: Workshop agenda

- Welcome - Mario Enrico Pé (Head of Institute of Life Sciences, SSSA, Italy)
- Computer models and water resource management: examples, perspectives, and a few opinions - Mary C. Hill (University of Kansas, USA)

- The MARSOL project - implementation and evaluation of managed aquifer recharge systems in southern Europe - Christoph Schüth (TU Darmstadt, Germany)
- The Horizon 2020 FREEWAT project: FREE and open source software tools for WATer management - Rudy Rossetto (SSSA, Italy)
- IAH MAR Commission's notice. Next coming activities related to MAR - Enrique Fernández Escalante (IAH MAR Commission Co-Chair, Tragsa, Spain)
- Modelling reactive transport with Lagrangian approaches: implications to human health risk - Daniel Fernández-Garcia (UPC, Spain)
- The UNESCO's Hydro Free and/or Open source software Platform of Experts (HOPE) initiative - from the design to the implementation - Youssef Filali Meknassi (UNESCO)
- JRC activities on water management in developing countries - Vasileios Markantonis (Joint Research Centre, EC)
- Model-based quantification of groundwater quality changes during managed aquifer recharge - Janek Greskowiak (University of Oldenburg, Germany)
- SID&GRID towards FREEWAT: GIS-integrated modelling tools for water resources management - Iacopo Borsi (TEA, Italy)
- GIS-based tools for hydrogeological analysis - Domitila Violeta Velasco Mansilla & Enric Vázquez Suñè (Institute of Environmental Assessment and Water Research - Spanish Council for Scientific Research IDAEA-CSIC, Spain)
- Evaluating processes, parameters and observations using computationally frugal sensitivity analysis and calibration methods - Laura Foglia (TU Darmstadt, Germany)
- MARSOL demonstration case-study areas: modelling studies to fulfil the aim of "comparable" modelling - João Paulo Lobo Ferreira (LNEC, Portugal)
- Reflections on challenges in coupling spatial databases, GIS and groundwater modeling tools, promoting more effective modelling practice - Ezio Crestaz (SAIPEM, Italy)
- Groundwater flow modelling application to Managed Aquifer Recharge (MAR) of Marecchia River alluvial Fan (Rimini, Italy): modelling approach for the feasibility study and for supporting experimental phases - Andrea Chahoud (Environmental Protection Agency Emilia-Romagna region ARPAER, Italy) & Paolo Severi (Emilia-Romagna Regional Authority, Italy)
- Discussion and Conclusions

5.4. Summary and conclusions

The main objectives of this workshop were 1) to gather a number of researchers, consultants, administrators and stakeholders interested in learning about how simulation models have been applied to address scientific and resources-management questions in Europe and in the US, 2) to present and discuss the importance of using numerical models for water resources management and, in Europe, for the implementation of the Water Framework Directive and related Directives, and 3) to promote the discussion about how to use models and how to present modelling results to different groups, such as stakeholders, decision makers.

The speakers presented their experiences providing guidelines on the importance of combining open source modelling approaches and stakeholders involvement in order to improve water resources management. Aside from presentations on recent research advancements, the focus was given to real case applications of modelling tools used to plan and manage the use of water resources, especially groundwater. Particular attention was given to demonstrate the use of these tools in Managed Aquifer Recharge issues.

Fig. 5: Presentations at the modelling workshop in Pisa, Italy.

5.5. Selected dissemination activities

Acque Sotterranee - Italian Journal of Groundwater:
http://www.acquesotterranee.it/it/rivista/joint-international-workshop-eu-fpvii-marsol-and-eu-horizon-2020-freewat-projects-within-eu

INOWAS MAR Junior Research Group, TU Dresden:
https://tu-dresden.de/bu/umwelt/hydro/inowas/project/news/advantages-of-using-numerical-modeling-in-water-resources-management-and-managed-aquifer-recharge-schemes-pisa-21-23-april-2015

DINA-MAR (IAH MAR Commission sister website):
http://www.dina-mar.es/post/2015/05/24/Imminent-Workshop-on-MAR-Advantages-of-using-Numerical-Modeling-in-Water-Resources-Management-and-Managed-Aquifer-Recharge-schemes.aspx

LinkedIn:
https://www.linkedin.com/pulse/advantages-using-numerical-modeling-water-resources-rudy-rossetto?redirectFromSplash=true

MARSOL website:
http://www.marsol.eu/70-0-Past-Events.html

6 Water Quality Workshop, Faro, Portugal, 2015

6.1. Basic data

Event name:

MARSOL Water Quality Workshop - Algarve Demonstration Site

Dates:

24 - 26 June 2015

Location:

Auditório Direção Regional de Agricultura e Pescas, Patacão, Faro, Algarve, Portugal

Partner(s) Organising:

Laboratório Nacional de Engenharia Civil (LNEC)

Universidade do Algarve (UAlg)

Terra, Ambiente e Recursos Hídricos (TARH)

6.2. Audience

In total, 50 participants attended the workshop.

The target audience of the workshop was set to be researchers as well as other stakeholders in the water sector such as industry/SMEs, authorities, and end users participants from Agência Portuguesa do Âmbiente, Águas do Algarve and Direção Regional de Agricultura e Pescas. The invitation for the workshop has been disseminated and extended to members of:

- EIP Water Action Group 128 - MARtoMARket Managed Aquifer Recharge Strategies and Actions
- The International Association of Hydrogeologists (IAH/AIH)
- Associação Portuguesa dos Recursos Hídricos (APRH)

As a representative of MARSOL's External Advisory Board (EAP) the consortium was pleased to welcome Dr. Yongcheol Kim from the Korea Institute of Geoscience and Mineral Resources (KIGAM), to the workshop.

6.3. Activities and Program

The workshop was organized in four sessions introducing the background, a specific Portuguese demonstration site session, another one addressed to all 8 MARSOL demonstration sites as well as a scientific session on water quality. Several Managed Aquifer Recharge (MAR) techniques, such as Soil-Aquifer Treatment (SAT) were addressed, as they are expected to be applied to Algarve aquifers. One major aim is to regain the good water quality status envisaged by the Water Framework Directive and the Portuguese Water Law in a near future.

A 34-pages field trip reader was produced and distributed among all participants.

24 June 2015

Sites visits during travel from the MARSOL mid-term meeting in Lisbon to the Algarve followed by a visit to the Algarve aquifer demonstration sites.

25 June 2015

- Welcome addresses - LNEC, DRAP, APA-ARH Algarve, Águas do Algarve, UAlg
- MARSOL project introduction - Karl Ernst Roehl (TU Darmstadt, Germany)
- Water quality issues during MAR. Impact on native groundwater, risk assessment and legal framework - Christoph Sprenger (Kompetenzzentrum Wasser Berlin GmbH, Germany)
- Water quality issues relevant to managed aquifer recharge - Christine Kübeck (IWW, Germany)
- Portugal's river basin management plans: Groundwater innovative methodologies, diagnosis, and objectives - João Paulo Lobo Ferreira (LNEC, Portugal)
- Water supply and sanitation in the Algarve - Helena Lucas & Joaquim Freire (Águas do Algarve, Portugal)
- Algarve surface and groundwater quantity and quality data assessment - Edite Reis & Maria Conceição Gago (APA-ARH Algarve, Portugal)
- Introduction to Algarve demonstration site - Teresa E. Leitão (LNEC, Portugal)
- Removal of some nutrients, toxic metals, metalloids and pharmaceutical from wastewater prior to MAR: soil-column experiments results in Portugal - Teresa E. Leitão, Tiago Martins, Ana Estela Barbosa & Maria José Henriques (LNEC, Portugal)
- Sustainable scenarios for groundwater quality in new irrigation agriculture sites in Portugal and Algarve scenarios for groundwater rehabilitation - João Paulo Lobo Ferreira (LNEC, Portugal)
- Use of electrical resistivity tomography for MAR: case-studies in Algarve - Rogério Mota (LNEC, Portugal)
- Interrelation of surface water and groundwater, including groundwater recharge assessment. The achievements of PROWATERMAN project - Manuel Oliveira & João Paulo Lobo Ferreira (LNEC, Portugal)
- Water quality issues at the Sant'Alessio Induced River Bank Filtration MAR scheme including micro pollutants issues - Rudy Rossetto, Alessio Barbagli (SSSA, Italy) & Christine Kübeck (IWW, Germany)
- Water quality issues at demo site Greece - Andreas Kallioras (ICCS, Greece)
- Water quality changes observed in column experiments with treated wastewater and a test soil from Athens - Matthew Silver (TU Darmstadt, Germany)
- Modeling emergent contaminant degradation under different redox conditions - Xavier Sanchez-Vila (UPC, Spain)

- Water quality evolution along a "triplet" MAR scheme: WWTP, canal green biofilter, artificial wetland - Enrique Fernández Escalante (Tragsa, Spain)
- Dissolution and ion exchange of Ca Mg and bi-carbonate due to MAR of desalinated seawater at Menashe site, Israel - Daniel Kurtzman (ARO, Israel)
- Characterisation of recharge (highly polished treated effluent) and receiving (groundwater) water in the Malta case study area - Manuel Sapiano (SEWCU, Malta)
- The conceptual and mathematical modeling of the hydrogeology of the Algarve - José Paulo Monteiro (UALG, Portugal)
- Results from infiltration and tracer experiments in the MARSOL MAR infrastructures in the Algarve - Tiago Carvalho (TARH, Portugal)
- Discussion and wrap-up of day 1

26 June 2015

- Pharmaceuticals fate and removal in MAR systems under different conditions: international literature review and evaluation on DEMEAU and DEMOWARE project - Ester Vilanova (Amphos 21, Spain)
- Simulation of an innovative enhanced system of MAR in Barcelona: results of column experiments & guidelines developed in DEMEAU project - Marta Hernández (Cetaqua, Spain)
- Relation between clogging processes distribution in Santiuste MAR system and its ground-water quality variations, Arenales aquifer, Spain. A current approach - Enrique Fernández Escalante (Tragsa, Spain)
- Artificial recharge through wells that Mekorot design to recharge surplus desalinated water - Yossi Guttman (Mekorot, Israel)
- Nitrate leaching to groundwater under agricultural land uses - Daniel Kurtzman (ARO, Israel)
- Water quality issues at several MAR sites in Korea - Yongcheol Kim (KIGAM, Korea)
- Discussion & wrap-up of day 2

6.4. Summary and conclusions

The overall objective of the MARSOL Water Quality Workshop, held in the Algarve, was to collect research results, practical experience, and innovative ideas related to water quality issues in MAR activities, and through this to contribute to the training of project participants' staff and researchers as well as other stakeholders in the water sector such as industry/SMEs, authorities, and end users. The workshop topic of "Water Quality" addresses changes and associated risks in the chemical status and hydraulic properties of water bodies due to infiltration of various water sources in MAR installations.

The workshop was organized in four sessions introducing the background, a specific Portuguese Demo Site session, another one addressed to all 8 MARSOL Demo Sites as well as a scientific session on Water Quality. Several Managed Aquifer Recharge (MAR) techniques, such

as Soil-Aquifer Treatment (SAT) were addressed, as they are expected to be applied to Algarve aquifers. One major aim is to regain the good water quality status envisaged by the Water Framework Directive and the Portuguese Water Law in a near future.

The Algarve Water Quality Workshop was considered a great success. 50 participants from all MARSOL demonstration sites, and also from the EIP AG 128 MARtoMARket and the DEMEAU and DEMOWARE FP7 projects contributed to achieving the aimed objectives addressing MAR techniques such as Soil-Aquifer Treatment (SAT). Besides these MARSOL partners, also Portuguese workshop sponsoring actors are now much more aware of the potentialities of MAR as part of the solution to Algarve water quantity and quality problems, for instance regarding the Campina de Faro aquifer with the aim of regaining in a near future the good water quality status envisaged by the Water Framework Directive and the Portuguese Water Law. This could be partly achieved by MAR, contributing as an alternative source of water, in the context of an integrated and inter-annual water resources management, solving groundwater quality problems caused by agricultural practices and wastewater discharges.

A description of the successful workshop has been included in the EIP Water news, containing all presentation made available in pdf to the general public.

Fig. 6: Participants of the Water Quality Workshop in Faro, Portugal.

6.5. Selected dissemination activities

All presentations from the workshop are accessible at the EIP Water Action Group's page under the "Documents" tab:
http://www.eip-water.eu/algarve-water-quality-workshop-great-success
http://www.eip-water.eu/MAR_Solutions

EMWIS - Euro-Mediterranean Information System on know-how in the Water sector:
http://www.emwis.org/thematicdirs/events/2015/06/marsol-water-quality-workshop-algarve-demonstration-site

LinkedIn:
https://www.linkedin.com/groups/7453856/7453856-6005714497128407042

Facebook:
https://www.facebook.com/marsolproject/posts/822139351204475

MARSOL website:
http://www.marsol.eu/70-0-Past-Events.html

7 Legal Issues, Policy and Governance, Malta, 2015

7.1. Basic data

Event name:

MARSOL Workshop on Legal Issues, Policy and Governance of MAR Activities

Dates:

21 - 23 October 2015

Location:

Head Office of the Water Services Corporation, Luqa, Triq Ħal Qormi, Ħal Luqa LQA 9043, Malta

Partner(s) Organising:

Sustainable Energy and Water Conservation Unit (SEWCU)

Water Services Corporation (WSC)

7.2. Audience

In total, 40 participants attended the workshop, including from all MARSOL demonstration sites, EIP AG 128 MARtoMARket, and the DEMEAU and DEMOWARE FP7 projects.

The audience of the workshop included, in addition to the project partners, representatives of:

- Regulatory Authorities: Malta Resources Authority, environment authority, and regulators for energy and water services
- Ministries: Ministry for Transport and Infrastructure, Ministry for Gozo, Ministry for Health
- Academia: University of Malta

Identified stakeholders from the above institutions were invited directly to the workshop.

As a representative of MARSOL's External Advisory Board (EAP) the consortium was pleased to welcome Prof. Jeff Camkin from the Centre of Excellence for Ecohydrology, The University of Western Australia, Perth, to the workshop.

7.3. Activities and Program

The workshop was organized over three days. The first day of the workshop focused on the presentation of the draft regulatory structure for MAR developed under WP17 and the contribution of the project's horizontal work packages to the development of the specific regulatory tests. The second day included site visits to the Malta MARSOL demonstration site at Ta Barkat, and the groundwater galleries at Ta Kandja. In the afternoon, the workshop discussed the application of the MAR Regulatory Structure to each pilot site under MARSOL. The workshop was extended on the third day when external stakeholders were invited to

participate in the meeting and discussions, and amalgamated with a site-visit to the Pembroke Sea-Water Reverse Osmosis Plant. Finally, an internal project management meeting was held.

21. October 2015

- Workshop Opening Session - Mr. William Wait, Executive Chairman of the Board of Directors of the Water Services Corporation (WSC), Prof. Christoph Schüth (MARSOL Coordinator, TU Darmstadt, Germany)
- Overview of WP 17 and the Draft Regulatory Structure for MAR - Manuel Sapiano (SEWCU)

Session 1: Horizontal Work Packages - contribution to the development of the regulatory tests:

- WP 11. Monitoring - George Athanasiou (ICCS, Greece)
- WP 12. Modelling - João Paulo Lobo Ferreira (LNEC, Portugal)
- WP 13. Technical Solutions - Enrique Fernández Escalante (Tragsa, Spain)
- WP 14. Water Quality (tbc)
- WP 16. Risk Assessment - Xavier Sanchez-Vila (UPC, Spain)

Session 2: Application of the Regulatory Structure to MARSOL Demo Studies:

- WP 10. Malta - Manuel Sapiano (SEWCU, Malta)
- WP 7. Brenta, Italy (tbc)

22. October 2015

- Visit to the Ta Kandja groundwater pumping station and Malta MARSOL demonstration site

Session 2: Application of the Regulatory Structure to MARSOL Demo Sites (continued):

- WP 3. Lavrion, Greece (tbc)
- WP 4. Algarve, Portugal (Joao Paulo Lobo-Ferreira, tbc, LNEC)
- WP 5. Arenales, Spain (Enrique Fernández Escalante, Tragsa)
- WP 6. Llobregat, Spain (Xavier Sanchez-Vila, UPC)
- WP 8. Serchio, Italy (Matteo Bonfanti, SSSA)
- WP 9. Menashe, Israel (Yossi Guttman, Mekorot)

23. October 2015

Session 3: EU Workshop on Regulation of Managed Aquifer Recharge:

- Workshop Opening Session - Mr. William Wait, Executive Chairman of the Board of Directors of the Water Services Corporation (WSC), Prof. Christoph Schüth (MARSOL Coordinator, TU Darmstadt, Germany)
- Overview of the MARSOL WP 17 on Legal Issues, Policy and Governance and its function within project - Manuel Sapiano (SEWCU, Malta)
- Legislative Framework. Review and Analysis - Matteo Bonfanti (SSSA, Italy)
- Draft Regulatory Approach for Assessing the Feasibility of Proposed MAR Schemes - Manuel Sapiano (SEWCU, Malta)

- Presentation of the detailed application of the regulatory scheme on the Malta and Italy MARSOL case study sites - speakers from SEWCU (Malta) and Provincia di Lucca (Italy)
- Open discussion - All
- Visit to the Pembroke Desalination Plant

7.4. Summary and conclusions

The application of MAR is highly dependent on a legal framework that supports its application on an EU wide scale. The Water Framework Directive (2000/60/EC) considers artificial recharge as one of the management tools which can be utilised by Member States for the achievement of good groundwater status. The provisions of this Directive are aimed at ensuring that the necessary controls are in place to eliminate the possibility of any degradation in the qualitative status of the receiving body of groundwater. In the same spirit the Groundwater Directive (2006) establishes specific measures for the assessment of good groundwater chemical status and complements the provisions preventing or limiting inputs of pollutants into groundwater (already contained in Directive 2000/60/EC), and aims to prevent the deterioration of the status of all groundwater bodies.

The overall objectives of the "MARSOL Workshop on Legal Issues, Policy and Governance of MAR Activities" was to analyse the normative framework which governs the creation and functioning of MAR schemes in Europe and in extra-EU countries, and to discuss the development of the MAR Regulatory Framework under the MARSOL Project. In particular, the scope of the workshop was to engage policy makers, regulators and site operators in a discussion on the practical application of the proposed MAR Regulatory Framework and thus address any identified implementation gaps. The workshop included presentations on the influence and impact of the following aspects and available techniques on a potential MAR regulatory framework:

- Technical solutions for MAR
- Monitoring techniques
- Modelling approaches
- Risk assessment techniques
- Water quality issues

The participants of the workshop discussed thoroughly the development of the MAR regulatory framework and its relation to the requirements of the Water Framework and Groundwater Directives. The discussions also focused on the application of the regulatory framework to the MAR pilot sites, where specific reference was made to the development of the regulatory tests and their practical application at site operation level, in terms of ease, practicability and reliability of the information required. The role of the project's horizontal work packages in the development of these regulatory tests, thus linking WP17 to the other horizontal work packages, was also discussed. The workshop on the last day of the meeting then, presented the opportunity for stakeholders from the regulatory, public and academic sector in Malta to discuss the regulation of MAR with the project partners.

The workshop enabled a detailed discussion on the draft MAR regulatory structure and provided significant insights on how it should be further developed to ensure a wide applicability in the different contexts in which MAR is applied. This was the main result which was expected from the project, which was achieved.

Fig. 7: Participants of the Malta workshop during site visit.

7.5. Selected dissemination activities

Josanne Cassar - Interviewing Malta:
http://josannecassar.com/events/marsol-project-leaders-meet-in-malta-to-discuss-methods-to-reduce-water-shortage/

DINA-MAR (IAH MAR Commission sister website):
http://www.dina-mar.es/post/2015/11/06/Workshop-sobre-aspectos-legales-legislacion-y-gobernanza-de-actividades-relacionadas-con-la-recarga-artificial-Malta-21-a-23-de-octubre-Workshop-on-Legal-Issues-Policy-and-Governance-of-MAR-Activities-21-23-October.aspx

LinkedIn:
https://www.linkedin.com/groups/4690290/4690290-6060698671182278656

Vimeo - collection of interviews made at the Malta workshop:
https://vimeo.com/album/3699705/

Facebook:
https://www.facebook.com/marsolproject/posts/897662723652137

MARSOL website:
http://www.marsol.eu/70-0-Past-Events.html

8 Investigation and Monitoring, Lavrion, Greece, 2016

8.1. Basic data

Event name:

MARSOL Workshop on Investigation and Monitoring Techniques in MAR

Dates:

16 - 18 March 2016

Location:

Lavrion Technological and Cultural Park (LTCP), French Mining Company Complex, Athens-Lavrion Avenue, GR 195 00, Lavrion, Greece

Partner(s) Organising:

Institute of Communication and Computer Systems (ICCS), Greece

Supported by UFZ, EPEM, EYDAP, and TUDa

8.2. Audience

The event has had 65 registered attendees from a record number of countries (there have been more than 20 countries represented from the five continents) plus a floating attendance for specific sessions. A significant number of the workshop participants were graduate students and young scientists.

8.3. Program

16. March 2016

MARSOL Project Presentations - Investigation and Monitoring Techniques:

- Coordinator's welcome - Christoph Schüth (MARSOL Coordinator, TU Darmstadt, Germany)
- Welcome address - Assimakis Chadoumelis (Site Manager LTCP)
- Overview of MARSOL project status - Christoph Schüth (MARSOL Coordinator, TU Darmstadt, Germany)

MARSOL Technologies - Presentations:

- Time domain reflectometry (TDR) technologies - Andreas Kallioras & Petros Kofakis (ICCS, Greece)
- Frequency domain (FD) measurement technologies - Jan Bumberger & Felix Schmidt (UFZ, Germany)
- Continuous wave & pulse radar systems - Nikolaos Uzunoglou (ICCS, Greece)
- Wireless sensor networks and applications - Jan Bumberger & Paul Remmler (UFZ, Germany)

MARSOL Technologies - Demonstration:

- Demo site visit 1: MARSOL developed technologies

MARSOL Demo Sites - Presentations:

- DEMO Site 2: Algarve and Alentejo, South Portugal - Tiago Carvalho (TARH, Portugal)
- DEMO Site 3: Los Arenales Aquifer, Castile and León, Spain - Enrique Fernández Escalante (Tragsa, Spain)
- DEMO Site 4: Llobregat River Infiltration Basins, Sant Vicenç dels Horts, Catalonia, Spain - Albert Folch (UPC, Spain)
- DEMO Site 5: River Brenta Catchment, Vicenza, Italy - Francesco Furlanis (SGI, Italy)
- DEMO Site 6: Serchio River Well Field, Tuscany, Italy - Rudy Rossetto (SSSA, Italy)
- DEMO Site 7: Menashe Infiltration Basin, Hadera, Israel - Yonatan Ganot (ARO, Israel)
- DEMO Site 8: South Malta Coastal Aquifer, Malta - Michael Schembri (SEWCU, Malta)

17. March 2016: Workshop Day - Monitoring & Investigation Technologies

Introduction Session:

- Coordinator's welcome - Christoph Schüth (MARSOL Coordinator, TU Darmstadt, Germany)
- Short introduction of workshop concept - Andreas Kallioras (ICCS, Greece)

Workshop Session Part I - Monitoring & Investigation Technologies:

- Life-Cycle of groundwater observation wells - Peter Dietrich (UFZ, Germany)
- Telemetric Radar Sensing Applications for Environmental Monitoring - Georgios Stratakos (ICCS, Greece)
- Organic contaminants in reclaimed water: From early warning to determination - Dimitris Iossifidis (GtG S.A., Greece)
- Modern subsurface investigation techniques - Thomas Vienken (UFZ, Germany)
- Open Discussion - All

MARSOL Technologies - Demonstration:

- Demo site visit: Direct Push technologies

Workshop Session Part II - Monitoring & Investigation Technologies:

- Data Management, Fusion and Analytics over Heterogeneous Environmental Data Anastasios Zafeiropoulos (UBITECH S.A., Greece)
- Radar Telemetric Monitoring Stations for Water Management in Greece Dimitris Kouvas (ScientAct S.A., Greece)
- Workshop Summary & Concluding Remarks - Christoph Schüth (TU Darmstadt, Germany) & Andreas Kallioras (ICCS, Greece)

18. March 2016: Field Trip Day

- Field visit to Athens Wastewater Treatment Plant, Psyttaleia Island (EYDAP, Greece)

8.4. Summary and conclusions

The overall objective of this workshop was to contribute to the training of project participants' staff, researchers, industry/SMEs, and other interested professionals to foster knowledge among all project partners and to ensure that the project's RTD and demonstration results effectively reach interested professionals. 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. These aspects have been examined through an integrated approach, including:

- New monitoring technologies (not commercially available)
- Commercial monitoring technologies that are cost and energy effective
- Data gathering, transmission, management & storage
- Critical environmental parameters in groundwater engineering (with respect to MAR facilities)

The workshop featured in-door sessions as well as participation in active field work and site visits. The event has had 21 presentations of the project partners who lead the eight demo sites involved, as well as external experts and various Greek and German agents 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.

A 16-pages printed flyer "Advanced Monitoring and Investigation Technologies for Managed Aquifer Recharge" was produced for the workshop and distributed among the participants. The flyer features the following contents:

- MARSOL objectives
- Technological & Cultural Park, Lavrion, Greece
- Direct Push for enhanced site characterization
- Wireless sensor networks
- MARSOL database management system
- Time and frequency domain sensing technologies
- Radar based sensing technologies

Fig. 8: Presentations at the Investigation and Monitoring workshop in Lavrion, Greece.

8.5. Selected dissemination activities

DINA-MAR (IAH MAR Commission sister website):
http://www.dina-mar.es/post/2016/03/08/MARSOL-Workshop-Investigation-and-Monitoring-of-MAR-Sites-Lavrion-Greece-16-18-March-2016.aspx

Grupo Tragsa - Noticias:
http://www.tragsa.es/es/comunicacion/noticias/Paginas/160330_Worshop_MARSOL.aspx?language_cd=es&pi=2&LA=-1

LinkedIn:
https://www.linkedin.com/groups/7453856/7453856-6113287007310532611
https://www.linkedin.com/groups/4690290/4690290-6120469680625901571

Facebook:
https://www.facebook.com/marsolproject/posts/969600836458325

Twitter:
https://twitter.com/MARSOL_Project/status/710120973744340994

MARSOL website:
http://www.marsol.eu/70-0-Past-Events.html

9 Water to Market Workshop, Venice, Italy, 2016

9.1. Basic data

Event name:

Water to Market: Financial and Economic Analysis of MAR Solutions

Dates:

6 June 2016

Location:

San Lazzaro, Strada S. Fortunato e Lazzaro, 182, 36061 Bassano del Grappa, Italy

Partner(s) Organising:

Alto Adriatico Water Authority (AAWA)

Studio Galli Ingegneria (SGI)

9.2. Audience

In total, 28 participants attended the workshop.

9.3. Program

Introduction session:

- Welcome address by the Chairman of Consorzio di Bonifica Brenta
- Workshop opening - Christoph Schüth (TU Darmstadt, Germany), Michele Ferri (AAWA, Italy) & Vincenzo Marsala (SGI, Italy)
- Financial Analysis of MARSOL sites - Marino Balzarini (SGI, Italy)
- Economic Analysis of MARSOL sites - Dimitris Damigos (EPEM, Greece)

Demo sites session - contribution to financial and economic analysis of MAR solutions:

- WP 3. Lavrion, Greece - Dimitris Damigos (EPEM, Greece)
- WP 4. Algarve, Portugal - Teresa Leitão (LNEC, Portugal)
- WP 5. Arenales, Spain - Enrique Fernández Escalante (Tragsa, Spain)
- WP 6. Llobregat, Spain - Xavier Sanchez-Vila (UPC, Spain)
- WP 7. Brenta, Italy - Marino Balzarini (SGI, Italy)
- WP 8. Serchio, Italy - Rudy Rossetto (SSSA, Italy)
- WP 9. Menashe, Israel - Daniel Kutzman (ARO, Israel) & Yoram Katz (Mekorot, Israel)
- WP 10. South Malta, Malta - Manuel Sapiano (SEWCU, Malta)
- Water to Market: Results, solutions and way forward. Recap and open discussion - lead by Clemens Strehl (IWW, Germany)

Field trip to the Brenta demonstration sites area:

- Visit to the Schiavon demonstration site - Michele Ferri, Alberto Cisotto (AAWA, Italy)
- Visit to the Loria demonstration site - Michele Ferri, Alberto Cisotto (AAWA, Italy)

9.4. Summary and conclusions

Objective of the workshop was to foster knowledge among all project partners about the outcomes of the financial analysis of the MARSOL demonstration sites and give a preview on the following economic analysis and ranking activities.

The workshop was complemented by the participation to COWM2016 - International Conference on Citizen Observatories for Water Management, Venice, 7 - 9 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. The participants gained awareness of the actual costs (overall and unitary costs) of MARSOL's demonstration MAR facilities, of the opportunity to recover these costs by selling the 'managed' water, and of the general benefits that can justify a MAR investment regardless its actual financial profitability. MARSOL partners involved in the WP 16 tasks gained useful additional information and comments on past and forthcoming activities.

The workshop was accompanied by a field trip to illustrate the forested infiltration area (FIA) approach and the win-win flood protection-MAR approach at the two Brenta area demonstration sites, and the monitoring system, modelling activities, and respective results were presented. The demonstration 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.

Fig. 7: Participants of the Water to Market workshop in Venice, Italy.

9.5. Selected dissemination activities

DINA-MAR (IAH MAR Commission sister website):
http://www.dina-mar.es/post/2016/05/23/MARSOL-Workshop-Water-to-Market-Financial-and-Economic-Analysis-of-MAR-Solutions-Venice-Italy-6-June-2016.aspx

LinkedIn:
https://www.linkedin.com/pulse/marsol-workshop-venice-paragon-europe-ltd
https://www.linkedin.com/groups/7453856/7453856-6148134176911613959
https://www.linkedin.com/groups/4690290/4690290-6143411779482451969

Facebook:
https://www.facebook.com/marsolproject/posts/979142702170805

Twitter:
https://twitter.com/ParagonEurope/status/739784986778324992

MARSOL website:
http://www.marsol.eu/70-0-Past-Events.html

10 Advanced Study Course (ASC), Barcelona, Spain, 2016

10.1. Basic data

Event name:

Managed Aquifer Recharge: Water Quality and Reactive Modeling

Dates:

7 - 9 November 2016

Location:

Universitat Politecnica de Catalunya (UPC), Campus Nord, Gran Capita, 08034 Barcelona, Spain

Partner(s) Organising:

Universitat Politecnica de Catalunya (UPC)

TU Darmstadt (TUDa)

10.2. Audience

The ASC was intended for graduate and post-graduate students, PhD students, and postdocs in the fields of geosciences, water research, environmental research, or related areas; it was also directed at professionals aiming at improving or broadening their qualification.

Participation was limited to 25 participants. For application, candidates had to send a brief CV and a motivation letter to the MARSOL coordinator.

Participation in the Advanced Study Course was free of charge. However, all travel and accommodation costs were to be covered by the participants.

A certificate of participation was issued at the end of the course to each participant.

10.3. Program

7. November 2016

- Welcome and introduction to the course - Christoph Schüth (TU Darmstadt, Germany)
- Fundamentals of Managed Aquifer Recharge (MAR) - Christoph Schüth (TU Darmstadt, Germany)

  The concept of MAR is presented and requirements for its implementation considering different water sources and different objectives are discussed. Also, the EU FP7 project MARSOL is introduced and an overview on the different field sites is given.
- Technical solutions for MAR systems - Enrique Fernández-Escalante (Tragsa, Spain)

  State of the art technical solutions for implementing various MAR systems are presented. Performances of the different designs are discussed and the experiences made during long-

term operation of such systems are presented, providing new advices on design, operation and management, not only at European but at international level.

- Water quality aspects of MAR - Christine Kübeck (IWW, Germany) & Christoph Schüth (TU Darmstadt, Germany)

  An overview on water quality aspects that have to be considered in MAR installations will be given with special focus on organic micropollutants. Entry pathways and fate of these contaminants are discussed based on hydrochemical boundary conditions.

8. November 2016

- Principles of water quality modelling during MAR - Henning Prommer (CSIRO, Australia)

  Fundamentals of solute transport and biogeochemical processes in the subsurface are presented. An introduction to geochemical and reactive transport modelling with special emphasis on MAR is given.

- MAR water quality modelling case studies - Henning Prommer (CSIRO, Australia), Paula Rodriguez (UPC, Spain)

  Different MAR case studies and the related modelling approaches are presented, including deepwell injection studies, groundwater replenishment with highly treated wastewater and ASR (aquifer storage and recovery) of reclaimed wastewater. Fate of pharmaceuticals and arsenic mobilization is discussed in detail as examples of reactive transport modelling of redox sensitive species.

- Hands-on modelling exercises - Henning Prommer (CSIRO, Australia), Paula Rodriguez (UPC, Spain) & Olivier Atteia (ENSEGID, France)

  Participants will setup, parameterize, and calibrate a conceptual reactive transport model for the modelling of redox zonation at MAR sites, and for the modelling of the fate of micro-pollutants and metalloids.

9. November 2016

- MAR in the Barcelona region - Xavi Sanchez-Villa, Albert Folch (UPC, Spain)

  Existing MAR installations in the Barcelona region will be presented, their monitoring and modelling concepts explained, and their performance discussed.

- Field visit of MAR installations in the Barcelona region - Xavi Sanchez-Villa, Albert Folch (UPC, Spain)

  The MAR site, located in Sant Vicenç dels Horts, 15 km south of Barcelona, consists of a settlement pond and a recharge pond. Water source is the local Llobregat River. A reactive layer has been installed at the bottom of the recharge pond in 2011 to enhance biodegradation of contaminants.

- Wrap-up meeting to summarise the course's contents and discuss open questions - All
- Handing out of participation certificates - All

10.4. Summary and conclusions

The overall objective of the Advanced Study Course was to contribute to the training of students as well as young scientists and professionals on scientific and technical issues of MAR, building on the outcomes and experiences achieved in the project. The course focus was laid on water quality issues and reactive transport modelling techniques for MAR sites.

In total 24 participants from 13 different countries (Afghanistan, Bangladesh, China, Columbia, Germany, Greece, India, Israel, Italy, Nicaragua, Peru, Spain, and USA) attended the course. One participant has a doctoral degree, 5 are PhD students, 5 are master's students, one has a bachelor's degree (working in an international water company for many years), and the remaining have master's degrees and work in companies or at universities. Most of the participants have an educational background in geosciences and hydrology, some in engineering. Incorporating a field site visit and modelling exercises, the course had a strong combination of theory and practise. With the diverse backgrounds of the participants, contributions came from different perspectives, making it an extremely interesting course. The class was filled with interactive contributions which increased awareness and technical knowledge of managed aquifer recharge solutions in different countries and settings.

Fig. 10: Participants of the MARSOL Advanced Study Course in Barcelona

10.5. Selected dissemination activities

EIP Water:
http://www.eip-water.eu/managed-aquifer-recharge-advanced-study-course

DINA-MAR (IAH MAR Commission sister website):
http://www.dina-mar.es/post/2016/11/04/MARSOL-Advanced-Study-Course-for-Young-Scientists-on-Managed-Aquifer-Recharge-Water-Quality-and-Reactive-Modeling.aspx

LinkedIn:
https://www.linkedin.com/groups/7453856/7453856-6170182642336555009
https://www.linkedin.com/groups/4690290/4690290-6197353748621197316

Twitter:
https://twitter.com/MARSOL_Project/status/764072900072644608

Facebook:
https://www.facebook.com/marsolproject/posts/1070640216354386

MARSOL website:
http://www.marsol.eu/72-0-ASC.html

11 Overall Summary and Conclusions

The eight training workshops and the advanced study course (Table 1) belonged to the core activities of the project with a high level of presentation, discussion, exchange of ideas, training, learning, communication, and networking. Target audience was in general personnel of the MARSOL partners and interested stakeholders from the water community including, e.g., farmers, irrigation community board members, industry, water and environment authorities, politicians, and even other technicians and researchers in the water sector, and graduate students. Partners from neighbouring EU projects such as DEMEAU (FP 7), DEMOWARE (FP 7) and FREEWAT (Horizon 2020) were invited and involved in the activities.

Table 1: Overview of the training workshops and the advanced study course

Place and date	Activity Titla
Arenales, Spain 29. - 30.10.2014	MAR4FARM Workshop
Tel Aviv, Israel 01. - 04.12.2014	MAR-SAT Workshop
Arenales, Spain 09. - 11.03.2015	MARenales - Technical Solutions on Managed Aquifer Recharge
Pisa, Italy 21. - 23.04.2015	Modelling of Managed Aquifer Recharge Processes
Algarve, Portugal 24. - 26.06.2015	Water Quality Aspects of Managed Aquifer Recharge
Luqa, Malta 21. - 23.10.2015	Legal Issues, Policy and Governance of MAR Activities
Lavrion, Greece 16. - 18.03.2016	Investigation and Monitoring Techniques in MAR
Venice, Italy 06.06.2016	Water to Market: Financial and Economic Analysis of MAR Solutions
Barcelona, Spain 07. - 09.11.2016	Advanced Study Course on Managed Aquifer Recharge: Water Quality and Reactive Modelling

The schedule of the workshops was to some extent influenced by external factors such as large conferences (e.g., EGU, IAH) or the availability of venues. The MAR-SAT workshop in Tel Aviv had to be delayed by three months due to the regional situation in the second half of 2014. However, all workshops could also be used for project management purposes, being accompanied by Steering Group or Core Group meetings.

At most of the workshops, members of the project's External Expert Advisory Panel participated and contributed to the discussions.

Such workshops, but also specialized courses directed at graduate students and young scientists, have proven to be a most useful tool for 'spreading the message', for exchanging ideas, and for networking. If included in research or demonstration projects, they should be given a substantial amount of resources to facilitate their successful organization at all levels, including preparation, advertisement, venue, catering, and documentation.