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

Large quantities of water are often lost 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, in principle, be used for the controlled re-filling of exploited aquifers by artificial recharge, referred to as Managed Aquifer Recharge (MAR).

Objectives of EU FP7 INNO-DEMO project MARSOL

- Demonstrate in 6 sites that 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 Europe industry and SME's (MARtoMARket);
- Promote the advantages of MAR by tailored training and dissemination programs to enable and accelerate market uptake;
- Deliver a key technology to face the challenge of increasing water scarcity in Southern Europe, the Mediterranean and other regions of the world.

PT2_6: DEMO site

Cerro do Bardo, Algarve, Portugal

The goal of MAR at Cerro do Bardo, Algarve, Portugal, test site consists in contributing to a regional integrated water management, by infiltrating part of the hydric surplus generated during the rainy season at the Funcho, Arade and Odelouca dams watersheds. Ideally, part of this water could be stored in the aquifer and contribute to the increase of groundwater levels in a highly explored aquifer for irrigation purposes. Thus, MAR activities at Cerro do Bardo will act as a preventive mitigation measure to climate change effects and the saltwater intrusion in the aquifer near Arade river/estuary.

R&D within MARSOL

During MARSOL project, R&D activities intend to assess:

- the infiltration capacity of the system in large dimeter wells, in sinkholes and river bed basins;
- flow direction and residence time of the infiltrated water;
- dimensioning and estimating the costs to build the necessary structures to transport water from the surface water reservoir system to the site.

Location of the well, sinkholes and wall - and the possible water sources for MAR at Cerro do Bardo

Infiltration test in a dolina to assess soil permeability

PT1: DEMO site

Campina de Faro, Algarve, Portugal

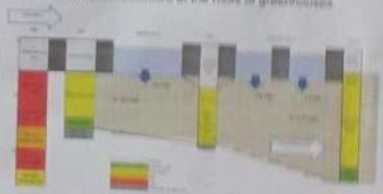
The goal of MAR at Campina de Faro, Algarve, Portugal, aquifer system consists in demonstrating the capacity to improve groundwater quality at the unconfined aquifer of Campina de Faro, regarding nitrate contamination originated from intensive agriculture (which in some places can reach up to 300 mg/l).

The techniques of MAR to be implemented comprise two methods: a) recharging the aquifer through infiltration basins located in Rio Seco riverbed with seasonal water flow as water source, and b) recharging the aquifer through infiltration in traditional 5 m large diameter wells with storm water collected at the roofs of greenhouses.

R&D within MARSOL

- During MARSOL project programmed works have been performed, namely:
- PT1_1 - Clogging test at the downstream Gabardine infiltration basin in order to assess the clogging generated between 2007 and 2014 (total area of 100 m²);
- PT1_2 - Construction of new MARSOL infiltration basin (total area of 200 m²);
- PT1_2 - Quantitative infiltration test at the MARSOL (200 m²) and GABARDINE (2 x 100 m²) infiltration basins in order to assess the infiltration capacity of the total MAR system;
- PT1_2 - Qualitative test of the MARSOL basin using salt as tracer in order to estimate not only the residence time, velocity and dispersion of the infiltrated water but also the infiltration capacity of this basin alone.
- PT1_3 - Infiltration test at a traditional large well (5 m in diameter) in order to assess the infiltration capacity.

River basin excavation: August 2014



Local conceptual model of the Rio Seco infiltration basins

PT2_4: DEMO site

São Bartolomeu de Messines, Algarve, Portugal, Wastewater Treatment Plant

At São Bartolomeu de Messines, Algarve, Portugal, WWTP, the main objective is to develop a SAT-MAR system to improve the water quality of treated effluents from the WWTP (PT2_4), prior to their current discharge into Ribeiro Meirinho river. This river is influent regarding the Querença-Silves aquifer system, in some reaches, contributing to the degradation of local groundwater quality.

R&D within MARSOL

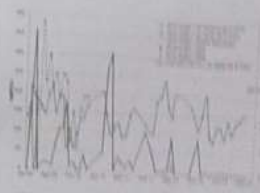
1st stage

- characterise the wastewater effluent main chemicals and pharmaceuticals in different occasions, as well as
- develop several soil-column experiments in LNEC laboratory facilities using different soils to evaluate the best suited soil to place at the bottom of the SAT-MAR basins.

2nd stage

- development of two SAT-MAR basins to treat part of the effluent, prior to its discharge into Ribeiro Meirinho, and further into Querença-Silves aquifer.

Scheme of the SAT-MAR planned for SB Messines

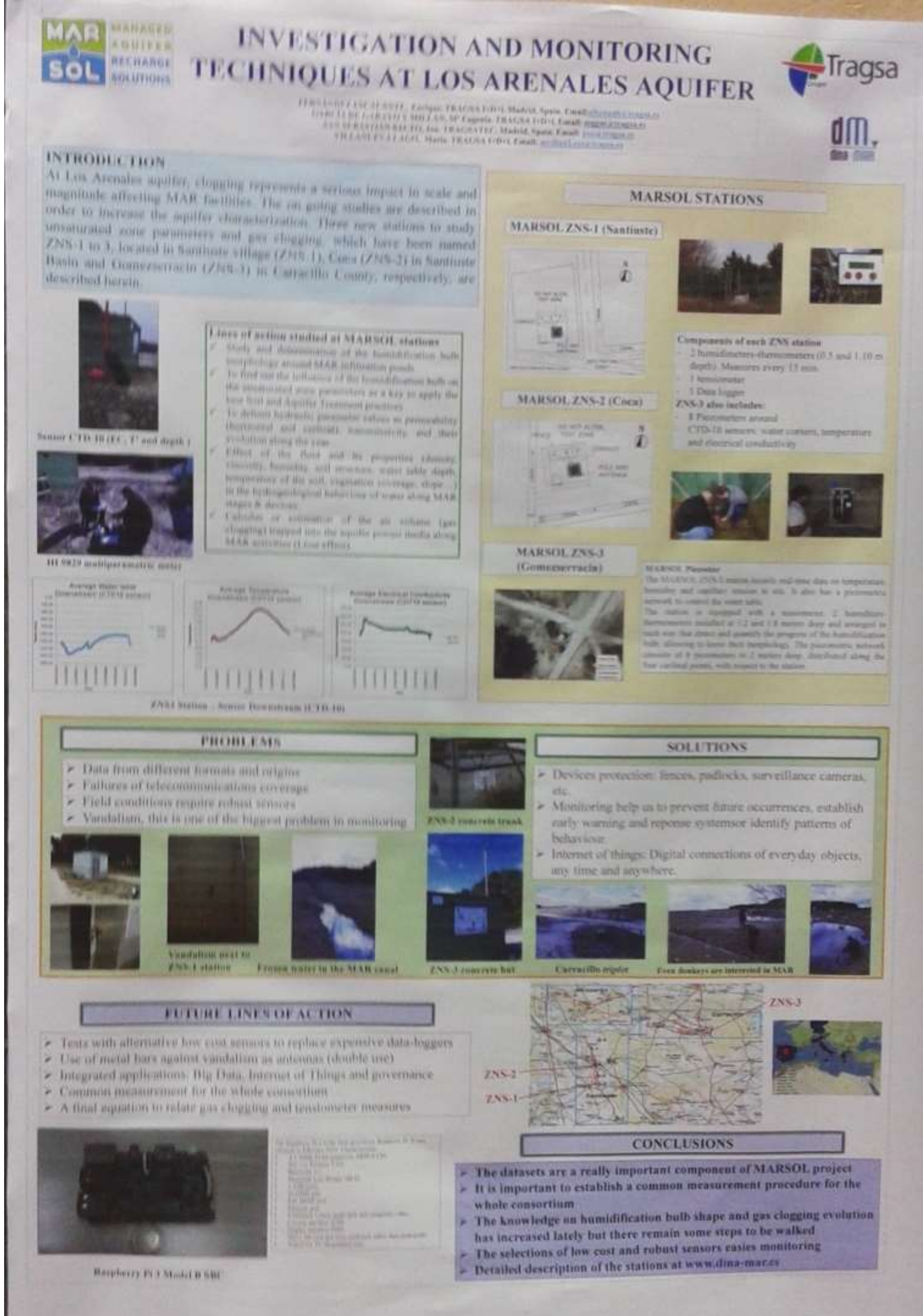


Nitrate and chloride concentrations at different locations

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no 619120 (Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought - MARSOL).

MAR SOL MANAGED AQUIFER RECHARGE SOLUTIONS

MARSOL DEMO SITE N.5
BRENTA - ITALY


MAR SOL
MANAGED AQUIFER RECHARGE SOLUTIONS
INVESTIGATION AND MONITORING TECHNIQUES AT LOS ARENALES AQUIFER
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dm.
INTRODUCTION
At Los Arenales aquifer, clogging represents a serious impact in scale and magnitude affecting MAR facilities. The on going studies are described in order to increase the aquifer characterization. Three new stations to study unsaturated zone parameters and gas clogging, which have been named ZNS-1 to 3, located in Santiuste village (ZNS-1), Coca (ZNS-2) in Santiuste Basin and Gomezserracín (ZNS-3) in Carracillo County, respectively, are described herein.
Lines of action studied at MARSOL stations
Sensor CTD-10 (EC, T° and depth)
HI 9829 multiparametric meter
MARSOL STATIONS
MARSOL ZNS-1 (Santiuste)
MARSOL ZNS-2 (Coca)
MARSOL ZNS-3 (Gomezserracín)
Components of each ZNS station
ZNS-3 also includes:
PROBLEMS
Data from different formats and origins
Failures of telecommunications coverage
Field conditions require robust sensors
Vandalism, this is one of the biggest problem in monitoring
ZNS-2 concrete trunk
SOLUTIONS
Devices protection: fences, padlocks, surveillance cameras, etc.
Monitoring help us to prevent future occurrences, establish early warning and reponse systemsor identify patterns of behaviour.
Internet of things: Digital connections of everyday objects, any time and anywhere.
Vandalism next to ZNS-1 station
Frozen water in the MAR canal
ZNS-3 concrete hut
Carracillo region
Even donkeys are interested in MAR
FUTURE LINES OF ACTION
Tests with alternative low cost sensors to replace expensive data-loggers
Use of metal bars against vandalism as antennas (double use)
Integrated applications: Big Data, Internet of Things and governance
Common measurement for the whole consortium
A final equation to relate gas clogging and tensiometer measures
ZNS-3
ZNS-2
ZNS-1
CONCLUSIONS
The datasets are a really important component of MARSOL project
It is important to establish a common measurement procedure for the whole consortium
The knowledge on humidification bulb shape and gas clogging evolution has increased lately but there remain some steps to be walked
The selections of low cost and robust sensors easies monitoring
Detailed description of the stations at www.dina-mar.es
Raspberry Pi 3 Model B SBC

Artificial recharge by highly polished treated sewage effluents for the management of coastal groundwater bodies

Michael Schembri – Sustainable Energy and Water Conservation Unit

INTRODUCTION

The overall objective of the Managed Aquifer Recharge (MAR) activities in the Malta South pilot-site is the development of a pilot sea-water intrusion barrier within the Malta South regional sea-level aquifer system. Groundwater abstracted from the southern region of the Malta Mean Sea Level aquifer system exhibits characteristically high chloride contents. This deterioration in quality has resulted from the intrusion of saline waters in response to the historically high groundwater abstraction rates registered in the area, particularly from the dense and widely distributed private abstraction for agricultural purposes. This situation has resulted in groundwater abstraction for public purposes from this region being discontinued since the early 1990's.

Through this pilot initiative, an attempt will be made to raise the regional piezometric levels of a section of the eastern coastal boundary of the aquifer system and develop a sea-water intrusion barrier with the aim of limiting the incidence of both lateral and vertical sea-water intrusion, thereby resulting in an improvement in groundwater quality in this section of the regional aquifer system.

PILOT SITE

The pilot site is located in the Malta South Wastewater Treatment plant. The location presents the typical hydrogeological characteristics of a coastal 'floating lens' aquifer system, in direct lateral and vertical contact with sea water.

The site is located on the coastal margin of a predominantly agricultural region, which has historically suffered from a shortage of water supply and groundwater degradation due to seawater intrusion. In fact, the use treated sewage effluent was introduced back in the 1980's in the area to augment the locally available water supply base.

Figure 1: Location of the Malta Pilot Site

METHODS

A monitoring program was set up to monitor the local and regional response of the groundwater system to artificial recharge. Monitoring was initiated with an assessment of the natural background conditions of the aquifer in the area.

The monitoring setup consists of four deep boreholes which traverse the whole length of the aquifer. A combination of pressure and float operated sensors are currently measuring the piezometric level of the aquifer and monitoring the freshwater and seawater interface of the aquifer system. The monitoring boreholes are located upstream of the artificial recharge boreholes at around 300 meters from the coastline. Artificial recharge of the coastal fringes of the aquifer is being carried out through a line of six boreholes located about 120 meters from the coast. The existing setup of the monitoring and recharge boreholes is shown in Figure 2.

Figure 2: Existing monitoring setup and multi-parametric groundwater probe

BASELINE CONDITIONS

The qualitative and quantitative results from the pilot site prior to the commencement of the recharge pilot area have been collated. Results from one of the monitoring boreholes are represented in Figure 3. Initial results indicate the high saline content of this regional aquifer system, with conductivity in the range of 3000(µS).

The piezometric levels of the aquifer are below the 1 meter mark and the aquifer exhibits a typical Ghyben-Herzberg profile with the groundwater turning increasingly saline at around 27 meters below mean sea level. The sharp interface of the conductivity profile indicates a relatively undisturbed aquifer system. These conditions allow for a better assessment of the changes measured in the aquifer following the artificial recharge of the aquifer with highly polished treated sewage effluent.

Figure 3: Preliminary results of groundwater level, conductivity and borehole profiling at monitoring borehole number MBH4.

REFERENCES

Government of Malta (2005). Initial Characterisation of Groundwater Bodies in the Mistras River Basin District.

Mangion, J. and Sapiano, M. (2006). The Mean Sea Level Aquifer, Malta and Gozo. in Natural Groundwater Quality, Blackwell Publishing 420-422.

Pedley, H.M., Hughes, M.R. and Waugh, B. (1976). The Geology of Malta and Gozo. Proceedings of the Geological Association 87, 325-41.

Pedley, H.M. (1978). A new lithostratigraphical and palaeoenvironmental interpretations of the Coralline Limestone formations (Miocene) of the Maltese islands. Overseas Geological and Mineral Resources, 54, 1-6.

Sceni, S. (2013). Geology of the Maltese Islands. Report in relation to the development of a 3D Numerical Model of the Mean Sea Level Aquifer in the island of Malta.

Sceni, S. (2002). On the correlation of fluoride levels in the Mean Sea Level Aquifer with the spatial occurrence of phosphorite conglomerate beds found in the Globigerina Limestone formation. Malta Resources Authority.

ACKNOWLEDGEMENTS

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SEWCU

MAR SOL

Lavrion Workshop Athens
16 – 18 March 2016

DEMO site 7:
Monitoring at Menashe Infiltration basin, Israel

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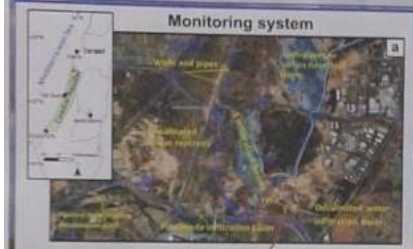
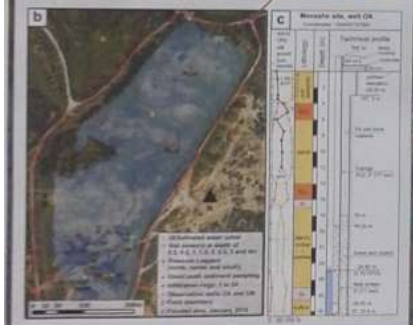
Introduction

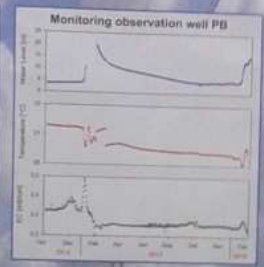
The increasing demand for fresh water combined with a series of long droughts in the last 35 years has led Israel to invest in large scale desalination plants. During 2016 these plants are planned to reach their full desalination capacity of ~600·10^6 m^3/year, which is ~75% of Israel's domestic water supply. Producing large volumes of desalinated water may provide operational and planned surplus that can be stored by recharge to the underlying coastal aquifer. In this work, managed aquifer recharge (MAR) of desalinated sea water from the Hadera desalination plant is studied.

Monitoring system

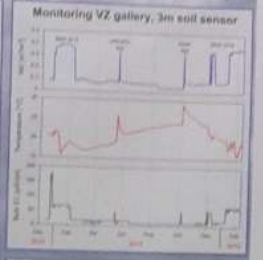




Monitoring observation well PB

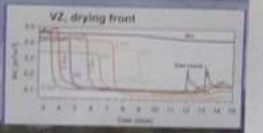


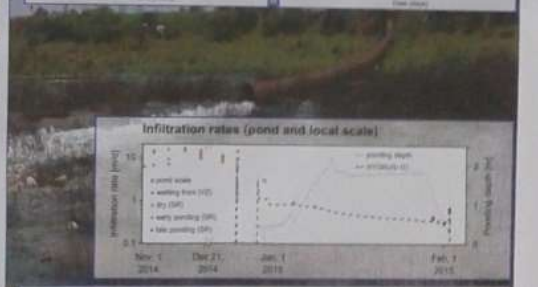
Monitoring VZ gallery, 3m soil sensor



VZ, wetting front

VZ, drying front





Infiltration rates (pond and local scale)

MAR events during MARSOL

MAR event January 2015

Geochemistry

(shallow GW beneath the pond are not a mix)

What else are we doing?

Tracer tests (sat.+unsat)

Column experiments

Modeling

Summary

- The vadose-zone and groundwater monitoring systems in the infiltration pond is continuously operating since the end of 2014 (Monitoring is automated. Data collection is manual)
- Monitoring reliability is maintained its robust commercial sensors
- Water quality data (VZ suction cups, GW sampling) is non-continuous and manually based

MONITORING AND CHARACTERIZATION ACTIVITIES THE ARTIFICIAL RECHARGE PILOT POND IN THE LLOBREGAT SITE (WP6), BARCELONA

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Hydrogeology Group (UPC-CSIC, Department of Civil and Environmental Engineering, Universitat Politècnica de Catalunya

MAR SOL MANAGED AQUIFER RECHARGE SOLUTIONS

FIELD SITE AND OBJECTIVE

To improve the groundwater quality by means of reactive layer installed at the bottom of the pond aimed at enhancing the coupled degradation of nutrients and emerging pollutants.

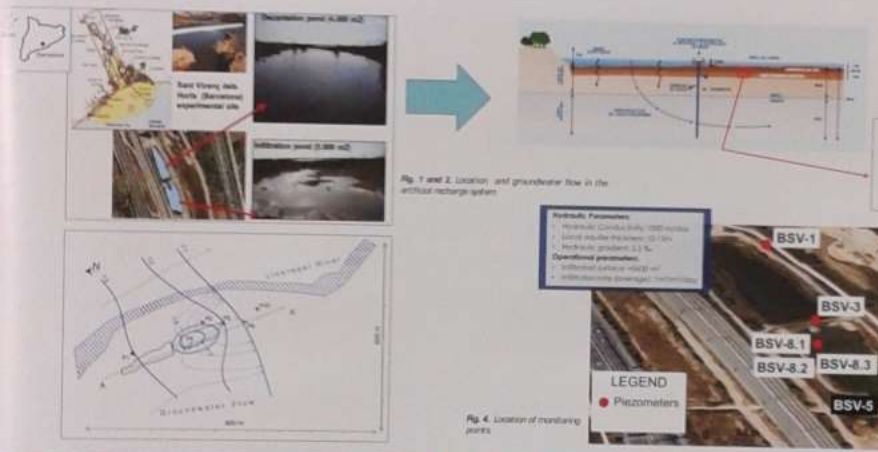


Fig. 1 and 2. Location and groundwater flow in the artificial recharge system

Fig. 3. General scheme of the infiltration pond system

Fig. 4. Location of monitoring points

MONITORING AND SAMPLING ACTIVITITES

Continuous monitoring of electrical conductivity, temperature and pressure

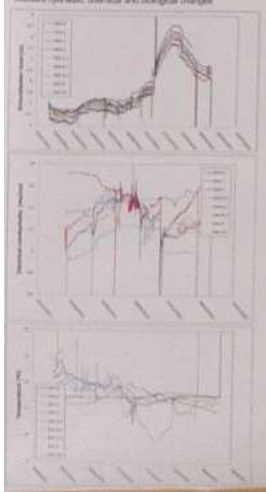


Fig. 5. Diverse parameters are measured continuously to evaluate hydraulic, chemical and biological changes

Monthly vertical multi-parametric profiles

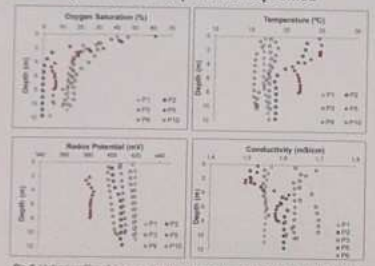


Fig. 6. Vertical profiles of oxygen saturation, temperature, redox potential and conductivity along the saturated zone are taken periodically to understand recharge process in the saturated zone. Measurements were taken during a recharge period on July 2014

Hydrochemistry and nitrate isotopes

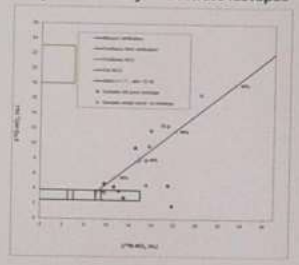


Fig. 7. Samples for hydrochemical analyses and nitrate isotopes has been collected. $\delta^{15}N$ vs. $\delta^{18}O(NO_3^-)$ plot for groundwater samples collected during a recharge period period (a) and during a non recharge period (b). Boxes represent the characteristic isotopic composition of main nitrate sources in the study area (Mongis et al., 2001). Estimation of the extent of the nitrate attenuation induced by the reactive layer. The slope of the solid line represents a value for ε_N of 1.7, obtained in the lab experiment

Microbial characterization

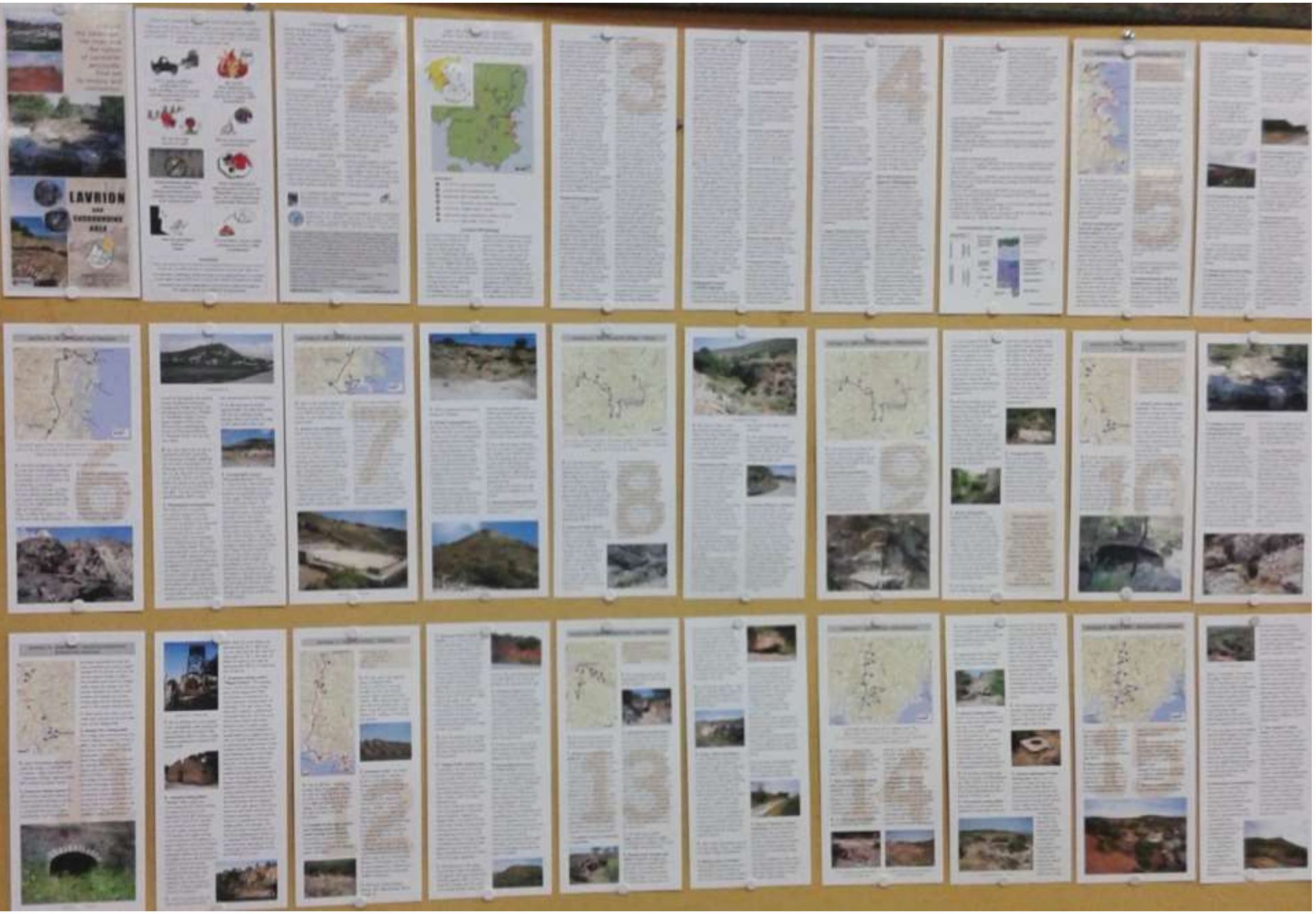
Fig. 8. A sampling campaign was carried out in July 2014 (wet) and march 2015 (dry) to compare microbial populations under different (non)recharging conditions. A total of 5 soil samples and 13 water samples with duplicates were analyzed. The sampling points were distributed along the sedimentation pond, reactive layer, vadose zone and groundwater (upstream and downstream at different depths). The 16S rDNA was amplified using primers for the domain Bacteria (341f-GC/907r) and products were resolved in DGGE gels.

Microbial population richness and equitability were measured from DGGE band profiles by the Shannon Index (H) and Pielou's Evenness Index (E). The former measures specific diversity of a natural ecosystem or community

Hydrogeology Group GHS eca idaea

UPC CSIC

UB Universitat de Barcelona


LAVRION

Integrated monitoring technologies for the management of a Soil-Aquifer-Treatment (SAT) system

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MAR SOL MANAGED AQUIFER RECHARGE SOLUTIONS

INTRODUCTION & OVERVIEW

Artificial recharge of groundwater has an important role to play in water reuse as treated wastewater effluent can be infiltrated into the ground for aquifer recharge. As the effluent moves through the soil and the aquifer, it undergoes significant quality improvements through physical, chemical and biological processes in the underground environment. Collectively, these processes and the water quality improvement obtained are called soil-aquifer-treatment (SAT) or geopurification (Fig. 1).

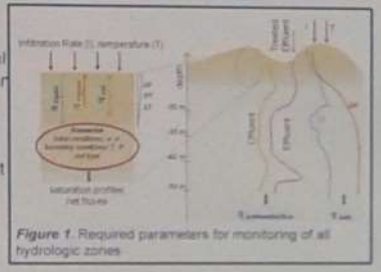

Figure 1. Required parameters for monitoring of all hydrologic zones

DEVELOPED MONITORING TECHNOLOGIES

The pilot site of Lavrion Technological & Cultural Park (LTCP) of the National Technical University of Athens (NTUA), involves the employment of plot infiltration basins at experimental scale, which will be using waters of impaired quality as a recharge source, and hence acting as a Soil-Aquifer-Treatment, SAT, system. The LTCP site will be equipped with new technological developments, which will be providing continuous monitoring of the quantitative and qualitative characteristics of infiltrating groundwater through all hydrologic zones (i.e. surface, unsaturated and saturated zone).

The development of an integrated system of sensing technologies, installed on-site (Fig. 2), offers continuous evaluation of the performance of the SAT system that proves the sustainability of all involved water quality treatment processes within unsaturated and saturated zone.

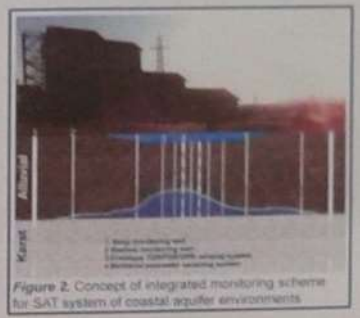

Figure 2. Concept of integrated monitoring scheme for SAT system of coastal aquifer environments

TDR/FDR DEVELOPMENT & ANALYSIS SOFTWARE

The prototype system of Time Domain Reflectometry (TDR) is shown in Figure 3. The TDR Analysis software enables the analysis of the TDR signal acquired by various TDR instruments. The software is a Microsoft Windows application (Microsoft .NET 4.5 Framework) designed to be instrument vendor neutral.

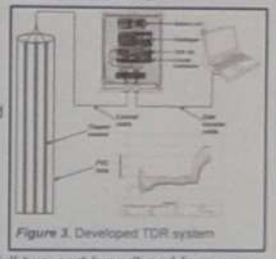

Figure 3. Developed TDR system

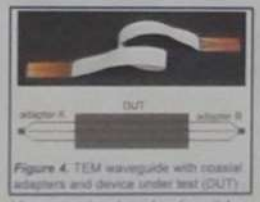

Figure 4. TEM waveguide with coaxial adapters and device under test (DUT)

A full two-port broadband frequency domain forward model for propagation of transverse electromagnetic (TEM) waves in coaxial waveguide has been implemented (Fig. 4). It is based on the propagation matrix approach for layered transmission line sections.

Homogenized and extensible storage of waveforms in a database system enables the selection (query) and correlation of waveforms and other measurements and meta-data according to criteria imposed by the user. Each waveform is automatically processed by the system (Fig. 5).

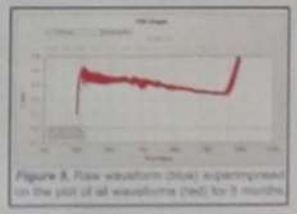

Figure 5. Raw waveform (blue) superimposed on the plot of all waveforms (red) for 5 months

ELECTROMAGNETIC RESISTIVITY TOMOGRAPHY MONITORING

Developed Electrical Resistivity Tomography (Fig 6.) setup with electrodes on surface and in two drillings at certain distances can fine detect the stratigraphy and moisture content fluctuations within the unsaturated zone.

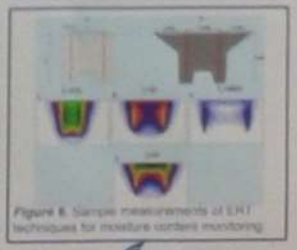

Figure 6. Sample measurements of ERT techniques for moisture content monitoring

DESIGN AND DEVELOPMENT OF RADAR BASED SENSORS

As a complementary monitoring technique, this research involves the development and construction of two different radar based sensors to achieve: (i) continuous wave radar as a tool to qualitatively assess the impacts of preferential flow in TDR measurements (Fig. 7) and (ii) pulsed Ground Penetrating Radar (GPR) for the monitoring of water table fluctuations within karstified conduit networks (Fig. 8).

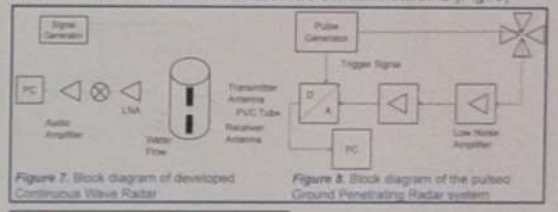

Figure 7. Block diagram of developed Continuous Wave Radar

Figure 8. Block diagram of the pulsed Ground Penetrating Radar system

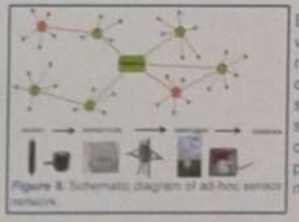

Figure 9. Schematic diagram of ad-hoc sensor network

Development and installation of wireless ad-hoc sensor to ensure reliable data acquisition. The combination with commercial sensors and/or other low-cost screening sensors (e.g. turbidity, conductivity) provides an open platform for a real-time monitoring of the system (Fig. 9).

SUMMARY

An integrated approach of the performance evaluation of any operating SAT system should aim at simultaneous monitoring of all hydrologic zones, proving the sustainability of all involved water quality treatment processes within the unsaturated and saturated zone.

ACKNOWLEDGEMENTS:

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

An Environment 2013 Cooperation Project funded by European Union's Seventh Programme for research, technological development and demonstration under grant agreement No [619120].

Institute of Communications and Computer Systems (ICCS)

National Technical University of Athens

TECHNISCHE UNIVERSITÄT DARMSTADT

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ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

ΤΕΧΝΟΛΟΓΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΛΑΥΡΙΟΥ

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

MAR SOL — MANAGED AQUIFER RECHARGE SOLUTIONS

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).**

1. Lavrion Technological & Cultural Park, Greece

⇨ Development and implementation of advanced sensors

- Treated wastewater effluents
- Infiltration basins
- Replenishment of exploited aquifer
- Combating seawater intrusion
- Soil Aquifer Treatment

2. Algarve and Alentejo, Portugal

⇨ River water infiltration at three sites

- Surface water
- Infiltration basins
- Wells
- Improving the ecological and chemical status of the aquifer

3. Arenales, Castile and Leon, Spain

⇨ River water infiltration in two catchments

- Surface water
- Treated wastewater effluents
- Infiltration ponds, artificial wetlands, drainage ditches
- Replenishment of exploited aquifer
- Soil Aquifer Treatment

Demonstration Sites

For the project eight demonstration sites have been selected to represent different MAR purposes and hydrological settings.

MARSOL follows an holistic approach, which considers different:

- **Recharge water sources**
- **Recharge techniques**
- **MAR objectives**

4. Llobregat River, Catalonia, Spain

⇨ River water infiltration basin

- Surface water
- Infiltration basin
- Replenishment of exploited aquifer
- Improving the ecological and chemical status of the aquifer

5. River Brenta Catchment, Vicenza, Italy

⇨ Agricultural area with a network of ditches

- Surface water
- Forested infiltration area
- Replenishment of exploited aquifer
- Improving the ecological and chemical status of the aquifer

6. Serchio River Well Field, Tuscany, Italy

⇨ River bank infiltration with an advanced monitoring network

- Surface water
- Induced river bank filtration
- Improving groundwater quantity and quality
- Continuous monitoring and automated operations

8. South Malta Coastal Aquifer, Malta

⇨ Create a seawater intrusion barrier at a coastal wastewater treatment plant

- Treated municipal sewage effluent
- Injection boreholes
- Combating seawater intrusion

7. Menashe Infiltration Basin, Hadera, Israel

⇨ Aquifer storage of surplus water from the Hadera desalination plant

- Desalinated water
- Infiltration basin
- Seasonal storage and aquifer storage recovery of surplus desalinated water

The Project

- 21 Partners
- 36 months, starting 12/2013
- Total budget ~ 8.0 million EUR
- EU contribution ~ 5.2 million EUR

MARSOL Project—Main Objectives

- **Demonstrate at 8 field sites that MAR is a sound, safe, and sustainable strategy** to increase the availability of freshwater under conditions of water scarcity
- Improve the state of MAR applications to enable **low-cost, high-efficiency MAR solutions** that will create market opportunities for European industry and SMEs (**MAR to Market**)
- Promote the advantages of MAR **by tailored training and dissemination programs** to enable and **accelerate market penetration**.
- Deliver a **key technology to face the challenge of increasing water scarcity** in the Mediterranean region of southern Europe and other regions of the world.

Tools to Reach the Objectives

- **Data collection**
- **Monitoring** (improvement of sensors, new sensors)
- **Improvement of MAR devices** (planning, design, and maintenance)
- **Modelling** (to simulate the impact of MAR on aquifer hydrology and hydrogeochemistry)
- **Scenario analysis**
- Development of a **Decision Support System**
- Definition of **guidelines and policies**
- Increase of public participation within **Public Private Partnership** (PPP) schemes
- **Market analysis** on the potential market exploitation solutions

www.marsol.eu

WHAT IS FREEWAT?

FREEWAT is an HORIZON 2020 project financed by the EU Commission under the call WATER INNOVATION: BOOSTING ITS VALUE FOR EUROPE. FREEWAT aims at promoting water resource management by simplifying the application of the Water Framework Directive and other EU water related Directives by means of innovative GIS integrated open source and public domain ICT simulation tools (the FREEWAT platform).

Main impact: *help produce scientifically & technically sound decisions and policy making* based on:

- data and innovative data analysis tools and
- support a participatory approach not only in the final stage of discussion but during the phase of scenario generation.

FREEWAT main result is an open source and public domain GIS integrated modelling environment for the simulation of water quantity and quality in surface water and groundwater with an integrated water management and planning module.

FREE and open source software tools for WATer resource management

EU HORIZON 2020 Project

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EIP Water Conference 2016

FREEWAT Current Development

The FREEWAT platform is integrated as a plugin for the QGIS GIS desktop. The core of the FREEWAT platform is the SID&GRID (Rossetto et al. 2013) framework ported to the QGIS desktop and complemented (June 2015) with solute transport (density dependent) capabilities in aquifers within the MARSOL (2014) EU FP7 project.

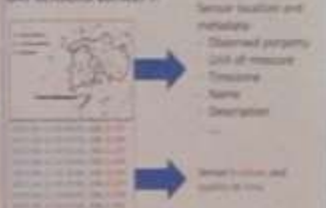
Observation-Analysis Tool (OAT)

New module developed to add a number of **time-series processing functionalities** for statistical analysis of observations and help **prepare model input data**.

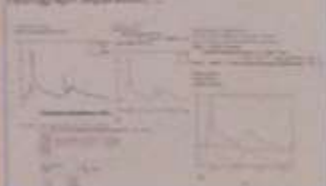
Module partially inspired by the TSPROC utilities (Westenbroek et al., 2012). It includes:

- analysis of raw data (regularization, data interpolation, fitting, filling, validation and data quality assessment);
- decomposition or filtering of time series (low, medium, high frequencies);
- aggregation and exceedance-time calculation, summary statistics and period statistics;
- hydrological indexes, goodness of fit, volume calculation, series calculation, etc.

OAT SENSORS CONCEPT



Fill, plot, resample, filter, exceedance time, hydrograph separation, ...



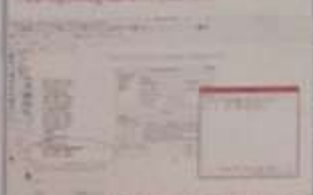
AkvaGIS

Hydrochemical Analysis Tools
Hydrogeological Analysis Tools

- Management and integration of a vast amount of time and spatial dependent data of different kinds (e.g. groundwater quality data, hydrogeological data, etc).
- Homogenization and harmonization of data collected from diverse sources gathered with different techniques.
- Communication and exchange of data of different formats.
- Management of data with diverse temporal and spatial ranges.

Hydrogeochemical analysis tool

Hydrogeological analysis tool



Create maps of hydrogeological values (head, abstractions...)

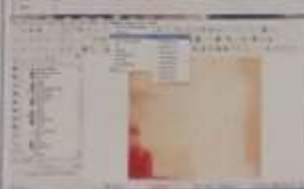
Flow & Transport model and Model Calibration

SID&GRID hydrological model

- Groundwater Flow (MODFLOW-2005) & Unsaturated zone flow
- Water flow in stream (1D Saint Venant eq.)
- Option to activate Local Grid Refinement(s)
- Overland flow → new package to be connected with UZF or VSF
- Heat and solute transport in the saturated zone (SEAWAT)

New in FREEWAT:

- Solute transport in the unsaturated zone: UZT-MT3DMS (recent development of MODFLOW)
- Specific modules for sensitivity analysis and calibration (UCODE_2014)
- Water & Irrigation management & crop growth module (based on MODFLOW-FARM package)



FREEWAT CONSORTIUM

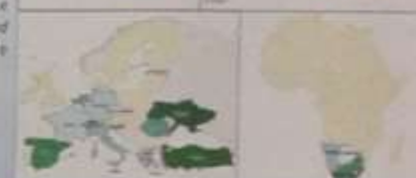
Partners

http://www.freewat.eu/

FREEWAT MAIN OBJECTIVES

1. coordinate previous EU and national research to integrate existing software modules for water management in a single environment and
2. support FREEWAT application in an innovative participatory approach gathering technical staff and relevant stakeholders (in primis policy and decision makers) in designing scenarios for the proper application of water policies. The open source characteristics of the platform makes this an initiative "*ad includendum*" as further research institutions, private developers etc. may contribute to the platform development.

FREEWAT will be applied to 10 case studies in the EU, 3 in neighboring countries (Switzerland, Turkey and Ukraine) and to a large trans-boundary aquifer in Africa. The case studies address different issues on WFD, GWD and other water related Directives and rural water management topics.



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References

MARSOL (2014). Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought www.marsol.eu [accessed 15 June 2015]

Rossetto, R., Borsi, I., Schifani, C., Bonari, E., Mogorovich P. & Primicerio M. (2013) - SID&GRID: integrating hydrological modeling in GIS environment - hydroinformatic system for the management of the water resource. Rendiconti Online Società Geologica Italiana Volume 24, 282-283

Rossetto, R., Borsi, I., Foglia, L., 2015. FREEWAT: FREE and open source software tools for WATer resource management. Rend. Online Soc. Geol. It., Vol. 35 (2015), pp. 252-255, doi: 10.3301/ROL.2015.113