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ABSTRACTS BOOK & PROGRAM 2019

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Large scale soil-aquifer-treatment (SAT-MAR) physical model experiments to remove rice paddy field contaminants

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KEY WORDS
Agriculture water reclamation, Soil-Aquifer Treatment (SAT), physical model, water reuse.

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ABSTRACT
The effluents from agriculture practices, namely from rice paddy fields, usually contain several contaminants creating an environmental concern to downgradient water bodies. The use of Soil-Aquifer-Treatment (SAT) systems to improve the effluents water quality, during the transport of infiltrated water through the unsaturated and saturated zones, can bring a solution for water reclamation, water reuse (e.g. for recharge), and overall as a water resources management tool.

The research described in this paper was carried out under MARSOL (Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought) EU project, whose main objective was to demonstrate that MAR is a sound, safe and sustainable strategy that can be applied with great confidence and therefore offering a key approach for tackling water scarcity in Southern Europe.

SAT-MAR experiments were developed in a physical (sandbox) model (3.5 m x 1 m x 2 m)[1] built during MARSOL project. These experiments aimed to contribute solving the problem of removing rice field contaminants from water, using a soil-aquifer prototype basin to treat water prior to its discharge in Melides lagoon, Alentejo, Portugal. The sandbox model was divided into three sections (A, B and C) to test the adsorption and degradation capacity of three soil profiles, two of them including soil mixtures of sand with vegetal compost with different layouts. In each section, two tracer experiments were performed with spiked fertilizer and hydrocarbons. To analyse the behaviour of the tracers, monitoring devices were installed in each section: two Prenart capsules, at 30 and 60 cm depth, and one piezometer with continuous *in situ* reading of T, EC, water level (and discrete analysis of pH and redox). Each section was modelled with FEFLOW using the data collected.
The results obtained in the SAT-MAR experiments gave useful knowledge necessary to build in the future an *in situ* SAT-MAR facility.

Figure – LNEC physical (sandbox) model

[1] http://www.lnec.pt/en/research/research-infrastructures/fluvial-hydraulics-experimental-facility/

New methodology to evaluate the risk failure of Managed Aquifer Recharge in Mediterranean region

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KEY WORDS
Risk-Assessment, Fault-Tree, Recharge, Mediterranean region

ABSTRACT
In this work, a methodology to evaluate the risk of failure of Managed Aquifer Recharge (MAR) has been developed. We applied it to six different facilities located in the Mediterranean Basin: Spain (2 sites), Portugal (1), Italy (1), Malta (1), and Israel (1). The methodology involves the development of a Probabilistic Risk Assessment based on Fault Trees. We considered different categories affecting the operation of the facility. Sixty-five events were defined and they were related to technical and non-technical aspects. When those basic events are combined they form more general events which finally, produce a global failure of the MAR installation when combined. The probabilities of the basic events were defined by expert criteria, based on the knowledge of the different managers of the facilities. It was found that the non-technical aspects can be the most significant ones, contributing more than the technical issues to the overall assessment of risk. We found out that in the facilities analyzed, the major contributors to overall risk were, in decreasing order of importance: Legal constraints, Social aspects, Economic constraints, Quantity issues, Structural damages, Specific targets and Quality issues. Regarding the results on perception of risk for the individual sites, it was surprising that three of them (the two Spanish facilities and the Portuguese one) above 0.90 in a 2-6 year period. The main contributors to failure were related to non-technical reasons and to quantity aspects. In fact, in recent years the three facilities had to be interrupted at least once, indicating that the evaluations provide reasonable estimations. Finally, the Malta site is a very recent one, with little history behind, and thus it is not possible to evaluate whether the perception of risk of 75% is high or low. On the other hand, the perceived risk for the other two sites, located in Italy and Israel, can be considered low (18% and 29%, respectively). One possible reason is that they are the oldest facilities, so experience has been accumulated for decades.

How to control groundwater quality degradation in coastal zones using MAR optimized by GALDIT Vulnerability Assessment to Saltwater Intrusion and GABA-IFI models

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KEY WORDS
Coastal zones, salt water intrusion, mathematical models, GALDIT, GABA-IFI

ABSTRACT
To counteract harmful, eventually with catastrophic consequences, today and future groundwater quality degradation due to saltwater intrusion into coastal aquifers, MAR is considered the best solution, a sound, safe and sustainable solution. MAR, in coastal areas, depends on the availability of water including waste water appropriately treated. How to control saltwater intrusion in coastal zones implementing a MAR facility? The parameters required to answer that question, include the selection of the most appropriate MAR technology and the best location for MAR. The appropriate location must have good infiltration rates; enough space to store underground the recharged water; guarantee that the travel time of the recharged water in the aquifer is long enough, compatible with the expected frequency of drought periods; economic efficiency maximization; availability of areas for MAR; and, positive impacts on the society. GABA-IFI model addresses those parameters allowing the selection of the most appropriate area for the location of MAR. Complementary, mathematical models are available to quantify MAR water injection rates required to recover groundwater depleted levels. But, GABA-IFI is not enough as an answer regarding coastal zones and the expected increase in sea levels worldwide. In those cases, we have to assess the most vulnerable zones to control groundwater quality degradation assessing vulnerability to saltwater intrusion. GALDIT is probably, today, the most used model worldwide towards that aim. GALDIT uses hydrogeological parameters such as aquifer properties, hydraulic conductivity, groundwater level, distance from the coastline, current severity of saltwater intrusion, and aquifer thickness to make saltwater intrusion vulnerability indices. GALDIT gives a weight to each of the indices, and prioritize the indices through a decision-making process, and then assess the possibility of saltwater intrusion by a numerical calculation. Examples will be presented.

An integrated system based on MAR and reclaimed water reuse for sustainable agriculture irrigation under climate change conditions in Mediterranean countries.

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KEY WORDS
MAR, ASR, SAT, agriculture, governance, monitoring system, ICT

ABSTRACT
The paper describes the conceptual scheme of an integrated system for sustainable management of non-conventional water resources through the smart integration of direct and indirect reuse practices, for increasing water availability via managed aquifer recharge & soil and aquifer treatment (SAT-MAR), using both treated waste water (TWW) and rainwater harvesting techniques (such as capturing excess winter flows).

The system aims to recognize, characterize, and offer solutions for overcoming the persisting barriers to the large scale implementation of SAT-MAR techniques in the Mediterranean region. The conceptual scheme will analyse relevant barriers such as regulatory frameworks, safety risks, economic concerns and social acceptance by adopting an innovative multi-actor, cross-border and multi-disciplinary approach involving local communities and experts from both EU and Mediterranean Partner Countries. Different capacities (isotopy, chemistry, microbiology, etc.) will be pooled together to develop knowledge and common innovative solutions to effectively integrate SAT-MAR techniques with reuse of TWW. Besides increasing the quantity and quality of non-conventional water resources for agriculture, innovation outcomes will support the achievement of sustainable and integrated water management strategies in the Mediterranean area, formulating practical and pragmatic solutions for making existing water infrastructure more climate resilient, efficient, cost-effective, environmentally beneficial, socially acceptable and sustainable. The system will contribute towards addressing water scarcity, environmental status, food security, nutrition, health, well-being and migration problems in the entire area, by supporting Mediterranean countries in a comprehensive capacity building process in the field of water resources management. This key transversal objective of this system will also be achieved through capitalisation activities for young and mid-career water researchers and practitioners. We envisage having the conceptual scheme tested in selected EU and Northern Africa Mediterranean countries, hopefully starting 2019.

Managed Aquifer Recharge Solutions (MARSOL). Final statements

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KEY WORDS
Managed Aquifer Recharge, Technical Solutions, Water Scarcity, Drought, MARSOL

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ABSTRACT
MARSOL project (Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought) has taken place since 2014 to 2017 within EC FP7 call with GA 619120. In the final part of the project, first row members put together the conclusions from their personal point of view and after three years of intense research. All these statements have been put together in a **seven minute video**, where authors expose their final statements.

As an example are included three of the whole set of summaries:

-Christoph Schüth (TUDA; GE): During the MARSOL project there are many experiences of the operation of the MAR sites most effectively to infiltrate different water qualities. However there are certain basins that we have to look into for the future, one is related to water quality of, for example, infiltration of emergent pollutants as pharmaceuticals, not so easy to predict; and the second one related objection is the regulatory framework that has to be implemented to ensure MAR safe and sustainable.

-Annette Wefer-Roehl (TUDA; GE): MAR is a sound, safe, and sustainable strategy for climate variability preparedness that can be used with great confidence, and through MARSOL and its demonstration sites the awareness and the acceptance among stakeholders for MAR solutions has been greatly increased.

-Jon San Sebastián (TRAGSATEC, SP): In the future the demand for water gained by MAR will be higher due to climate change, energy issues, increase of population etc. In general, economics is also an issue. Does MAR present a cost benefit? For the EU we have to present suggestions for the future. We have to link people and economy to MAR.

The first author collected and produced a video, concluding the following outcomes:

- MAR works, but needs experts to do it
- MAR is now a proven technology
- MAR is key solution to ecosystems depending on groundwater
- MAR is a sound, safe, and sustainable strategy that can be used with great confidence
- MARSOL has created a new generation of water managers that have an additional option now
- The awareness and the acceptance among stakeholders for MAR solutions is greatly increased
- MAR as one of the best techniques to face frontally climate change adverse impacts.

Authors request a 7 minute slot to display publicly this final video (subtitled). The paper will include two additional statements.

Note: 7 minute slot (Flash presentation) is requested for ISMAR 10 second Flash session.

MARSOL Policy Brief. Essentials on Managed Aquifer Recharge for policy makers and water managers

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KEY WORDS
MAR, regulations, MARSOL, policy

ABSTRACT
The European Water Framework Directive (2000/60/EC) considers 'artificial recharge' of groundwater as one of the water management tools that can be used by EU Member States to achieve a good groundwater status. It has to be ensured, however, that the necessary regulatory controls are in place to warrant that such practices do not compromise quality objectives established for the recharged or augmented groundwater body. It is also acknowledged by the Groundwater Directive (2006/118/EC) that it is not technically feasible to prevent all input of hazardous substances into groundwater, in particular minor amounts which are considered to be environmentally insignificant and thus do not present a risk to groundwater quality. For such cases the Groundwater Directive, under Article 6(3)(d), introduces a series of exemptions. Artificial recharge is considered as one of these exemptions. MARSOL suggests a Regulatory Framework based on risk assessment, control mechanisms and monitoring as a tool which can facilitate the application of the Water Framework and Groundwater Directives on MAR. It is the intention of such a regulatory framework to provide clear guidelines to Member States on the application of MAR techniques.

What are the costs?
MAR operations have to be economically feasible and apply simple engineered solutions that are easy to maintain, otherwise it will not be implemented. The financial feasibility of MAR projects depends on a number of parameters affecting their costs, such as capital expenses and operating costs, and the revenues potentially derived from the sales of the water for a variety of uses. However, water has also social and environmental values that are difficult to quantify. The benefit of a MAR project should not be solely based on market revenues. MAR projects can improve the quality of lives of the people benefiting from an increased availability of water, and recharged water can contribute to sustained ecosystem services. A thorough cost-benefit analysis is required to justify a MAR installation. However, MARSOL could prove that MAR can be a cost effective tool.