

Managed Aquifer Recharge using reclaimed water. Knowledge's advance thanks to modeling. Insights from an R&D project at Majorca island (Spain)

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Introduction

- Managed Aquifer Recharge (MAR) is a promising set of techniques to improve IWRM and cope a variety of water management-related issues.
- Regarding groundwater quality, one of the gaps for MAR implementation is the lack of clear regulations addressing MAR in many countries.
- Early-MAR countries usually adopt the WHO guidelines when developing new MAR activities.
- In this presentation some consideration about the binomial GW quality-MAR is addressed within the context of the SAT-MAR project EARSAC, considering also IT aspects and the MAR legal framework.

Guidelines for Drinking-water Quality
THIRD EDITION
Volume 1 Recommendations
WORLD HEALTH ORGANIZATION Geneva 2004



MAR in an irrigation crop-land

MAR water quality. International background MAR regulations. Analyses and comparisons





Maximum allowable Concentrations or MACs

18 countries which have or are developing legislation on MAR water quality, either at the regional or national level

Number of parameters per legislation with water quality standards analysed

The total number of parameters included in the ten reported water quality standards is 255

5/18 countries have specific SAT-MAR regulations

EARSAC project's objectives and lines of action

The main target is the setting and study of an **INTEGRATED SYSTEM** combining crops, soils and aquifers irrigated with water from different systems, specially reclaimed water



3.







- 1. Effects on plants physiology, production and quality (irrigated with reclaimed water)
- 2. Effect on the soil



Groundwater characterization and study of the evolution for the groundwater-reclaimed water system





- 4. Evolution of the water stored in irrigation dams Vs in the aquifer
- 5. **Water quality variations during disinfection and filtration** actions and evolution, etc.



-Richards equation (retention curves relating water content and hydraulic properties

$$\rho\left(\frac{C_m}{\rho g} + S_e S\right)\frac{\partial p}{\partial t} + \nabla \cdot \rho\left(-\frac{k_s}{\mu}k_r(\nabla p + \rho g \nabla D)\right) = Q_m$$

-Van Genuchten empirical model (COMSOL APP) (Van Genuchten, 1980).

$$\emptyset \frac{\partial c_i}{\partial t} + c_i \frac{\partial \emptyset}{\partial t} + u \cdot c_i = \nabla \cdot \left[\left(D_{D,i} + D_e \right) \nabla c_i \right] + R_i + S_i$$

Using super-computing centers to study water quality evolution



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X: 369478.4 Y: 4570088.8 Z: 758.0 Row (I):

Column (J): Laver (K):





Saving time in calculations... and money

Characterization and GW quantity results





3D isolines and 2D profile + results in steady-state regime.

Superficial aquifer (60-100 m interval) and deep aquifer (55-10 m interval)

GW quality results **Chlorides and DOC evolution for two time horizons**



Chlorides spatial distribution



Organic content (TOC) evolution and distribution



Sulphates evolution





Sulphates concentration's evolution in different water points for 5 year simulation period.

-Points: direct measures -Continuous line: simulation









Conclusions and recommendations

EVERY multi-barrier and multi-level approach should be "aquifer-wide" ar

and consider:

Hydrogeochemical criteria water sources (e.g. river, rainwater...)

MAR technologies (basin, flooding, wells, boreholes, combinations...)

The final use (irrigation, drinking water...) and its feasibility in economic and politic terms

Concrete monitoring guidelines, considering the cost of the analyses, the sampling frequency & the exact point/s for each aliquot.

IT aspects and super-computing systems are an asset for SAT-MAR, considering the vast amount of emerging compounds interacting with synergistic effects







25 MAR technologies:

https://www.ismar10.net/wp-content/uploads/2020/09/D1-05-02inventario-25-EN.pdf

 $https://www.ismar10.net/wp-content/uploads/2020/09/D1-07-conditioning-factors_EN.pdf$

Modeling and supercomputing centers are improving decision making basement for wiser MAR designs and regulations

To broaden this info:



EFECTO DEL REGADÍO CON AGUAS REGENERADAS SOBRE LOS SUELOS, ACUÍFEROS Y CULTIVOS





RESULTADOS DEL PROYECTO DE I+D+i EARSAC



https://bit.ly/3gLaiTs

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Regulations and guidelines on water quality requirements for Managed Aquifer Recharge. International comparison

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https://www.acquesotterranee.net/index. php/acque/article/view/462

PDF

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IAH-MAR or Managing Aquifer Recharge Commission





Attendees at ISMAR10, Madrid, May 2019 - the latest triennial symposium of IAH-MAR, UNESCO and ASCE

Welcome to the website of the International Association of Hydrogeologists Commission on Managing Aguifer Recharge (IAH-MAR). Here you can discover what our working groups are doing and contribute to their current projects, you can download resources on MAR, connect with people, get information on symposia coming up, and join our email list to stay informed of latest news. We also have sister sites in Spanish and Chinese

Managed Aguifer Recharge

Managed aguifer recharge, also called groundwater replenishment, water banking and artificial recharge, is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit. It embraces methods such as riverbank filtration, stream bed weirs, infiltration ponds and injection wells, and uses natural water sources and appropriately treated urban stormwater, sewage and other waste waters to increase groundwater storage, protect and improve water quality, and secure drought and emergency supplies. Its growing scientific base supports its rapidly increasing use as a vital management tool in the sustainable use of the world's water resources.

Latest News



National Seminar on "Resilience of Groundwater Resources for Accommodating Changing Climate Scenarios" – 7 November 2020 in New Delhi

CURRENT PROJECTS THAT YOU CAN

International

Association of

Hydrogeologists

RESOURCES

- New working group: MAR in Conferences. Coordinator: Daniela Benedicto van Dalen
- New working group: Urban MAR. Coordinator: Niels Hartog
- LatinMAR Community of Practice a new initiative to advance. MAR in Latin America Coordinator: Adriana Palma
- MAR Suitability Mapping Working Group, Coordinator: Jose Bonilla
- Contributions to a second monograph on cloggingfocussing on its management -Clogging Working Group. Coordinator: Russell Martin
- Groundwater Solutions Initiative for Policy and Practice (GRIPP) a Collaborative International Project, Coordinator: Karen Villholth

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https://recharge.iah.org/