ONLINE CONFERENCE IWRA 2020

Theme 2 (2-8) MAR

Water quality regulations and guidelines for Managed Aquifer Recharge

International synopsis, contrast and lessons learned


Foto: S. Kissane (L&M)

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Tragsa GrupoTragsa

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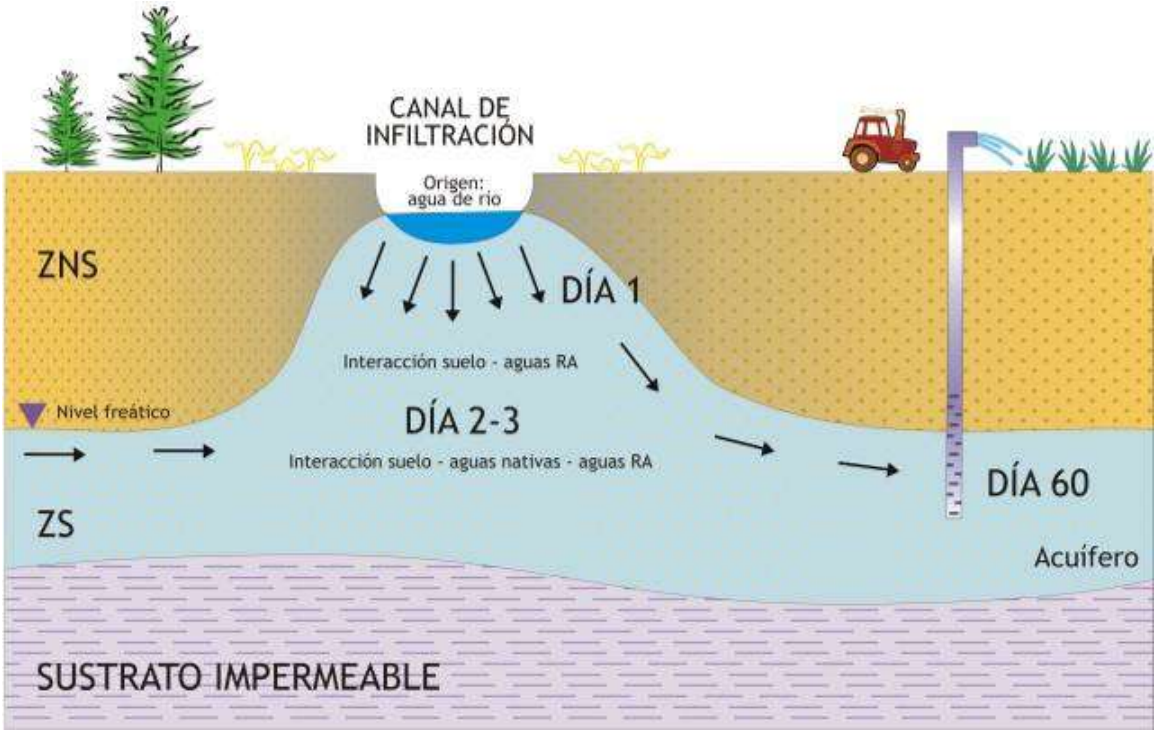
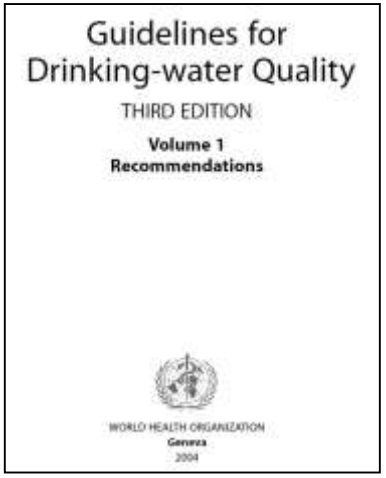
Introduction

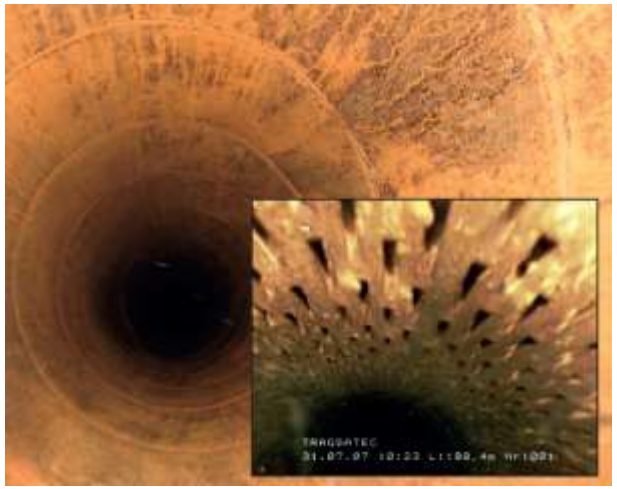
- ✓ **Managed Aquifer Recharge (MAR)** is a promising **set of techniques to improve IWRM** and cope a variety of water management-related issues.
- ✓ One of the **gaps for MAR implementation** is the **lack of clear regulations** addressing MAR **in many countries**.
- ✓ **Early-MAR countries usually adopt the WHO guidelines** when developing new MAR activities.
- ✓ In this paper presentation, **18 regulations (including guidelines) on water quality standards have been benchmarked** to propose advices for future MAR legal framework and policies development.



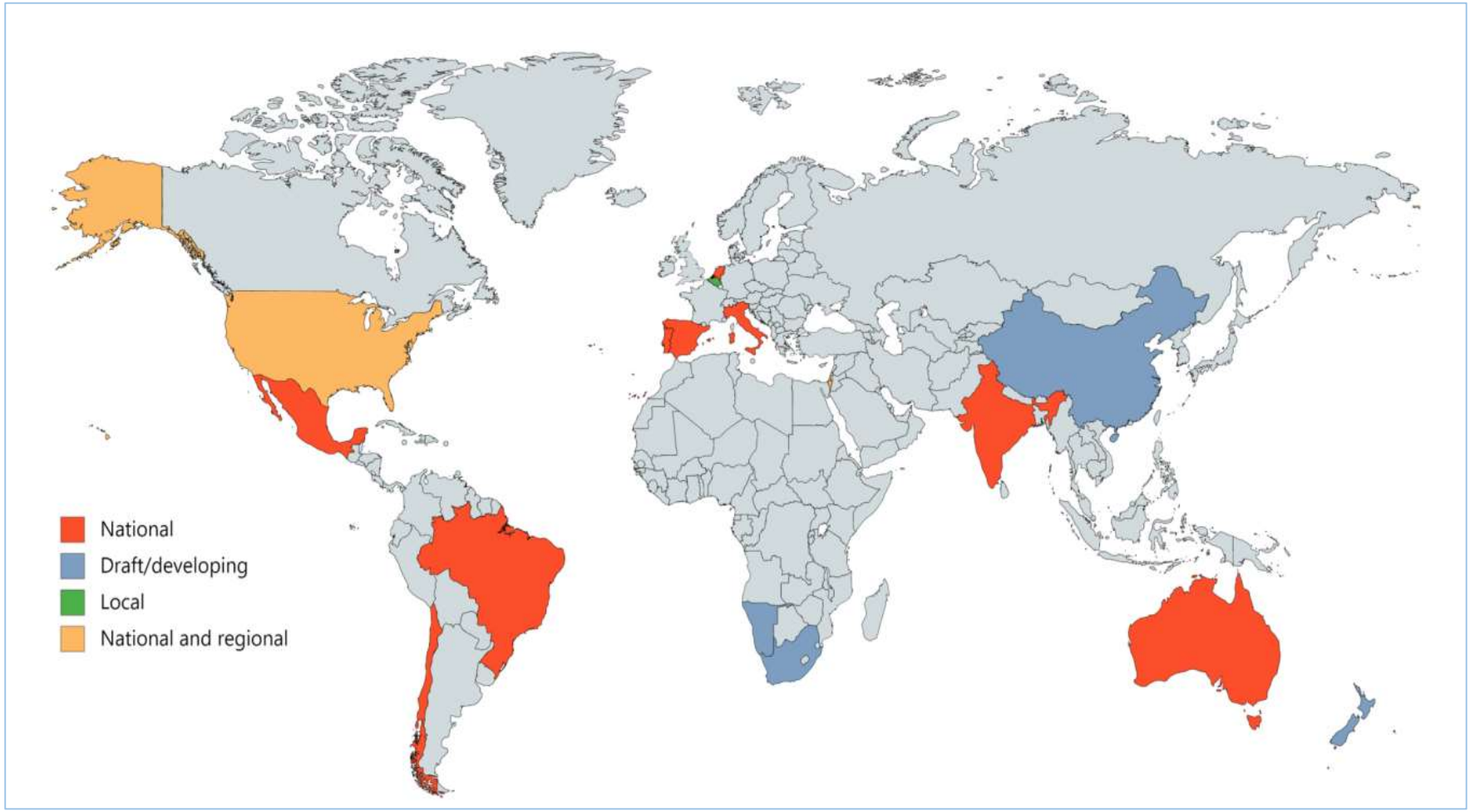


Methodology

- ✓ **18 existing regulations** and guidelines from five continents have been **gathered, studied and compared**
- ✓ **Identification** of huge **differences**, weaknesses and strengths
- ✓ **Economic, environmental, technical and scientific** considerations



MAR regulations. Analyses and comparisons



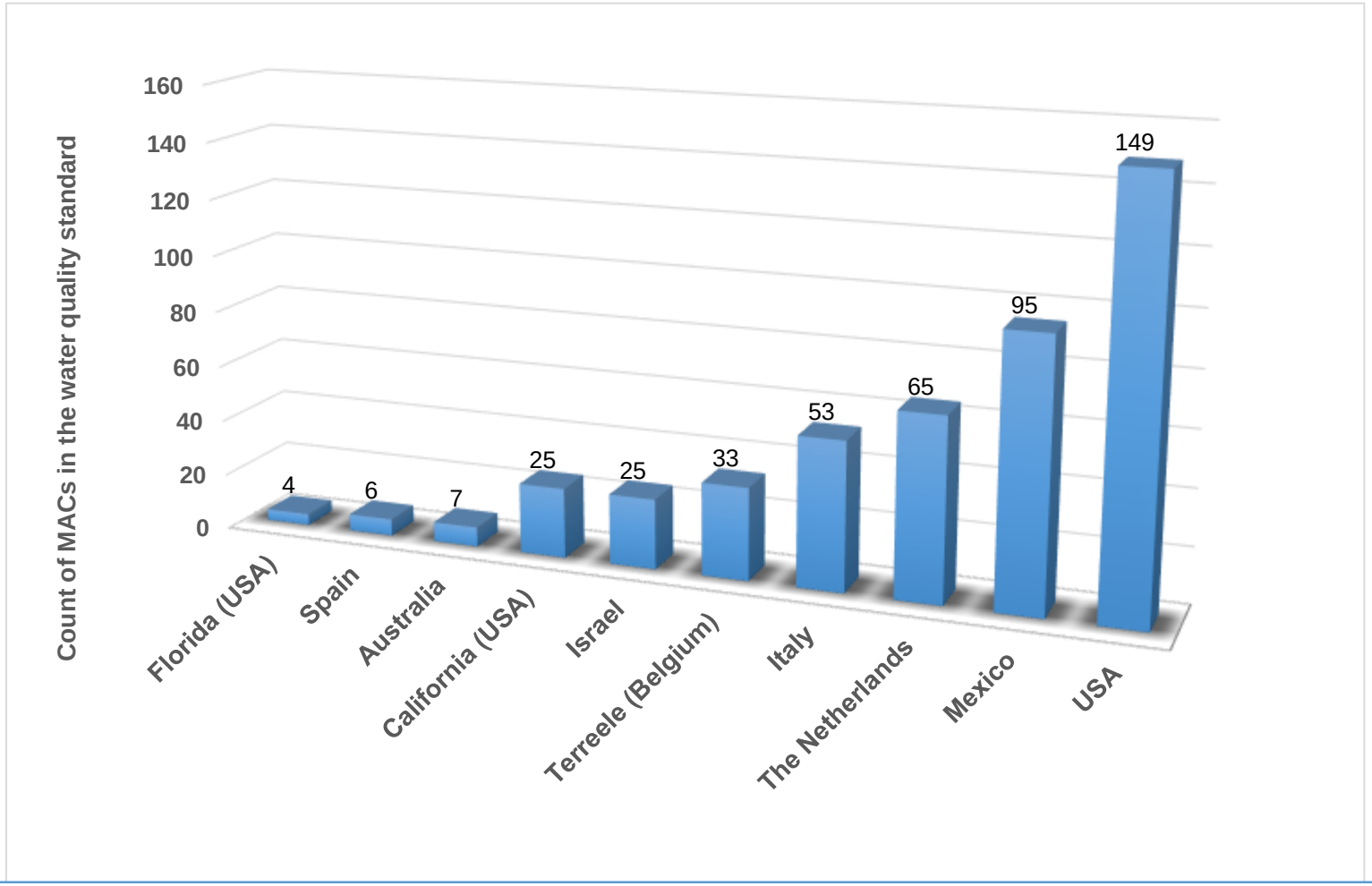
18 countries which have or are developing legislation on MAR water quality, either at the regional or national level

Characteristics of the regulations, guidelines and operator rules reviewed

Country	Scope	Soft/hard (10)	Type (Reg. 10)	Year	MACs (10)	Most used MAR techniques
Arizona (USA)	Regional	Hard	Guidelines	1994		ASR*, basins
Australia	National	Soft	Guidelines	2009	X	ASR, basins
California (USA)	Regional	Hard	Guidelines	2012	X	ASR, SAT-MAR
Chile	National	Soft	Regulation	2013		Multiple
Florida (USA)	Regional	Soft	Guidelines	1999	X	ASR, basins
India	National	Soft	Draft Guidelines	2014		Multiple
Italy	National	Hard	Regulation	2016	X	RBF**
Mexico	National	Hard	Regulation	2003 & 2009	X	Basins
Portugal	National	Hard	Regulation	2000		Multiple
South Africa	National	Hard	Draft regulation	2004		Basins, ASR
Spain	National	Hard	Regulation	2007	X	SAT-MAR*** (reuse)
The Netherlands	National	Hard	Regulation (under review)	1993	X	SAT-MAR, dunes, ASR
Israel (Shafdan)	Local-National[1]	Hard	Operator rules	From 1966	X	SAT-MAR, basins
Torreele (Belgium)	Local	Hard	Operator rules	2012	X	SAT-MAR, dunes
USA	National	Soft	Regulation	1974 & 2019	X	ASR, multiple
WFD	International	Soft	Regulation	2000		Basins, ASR
WHO guidelines*	-	Soft	Guidelines	2001		SAT-MAR (reuse)
Windhoek (Namibia)	National	-	Guidelines. Regulation proposal	2004		Interdune basins, ASR

Results

Study and Accountability of the most frequently regulated parameters in the world up to date, the different considerations on emergent pollutants, etc.

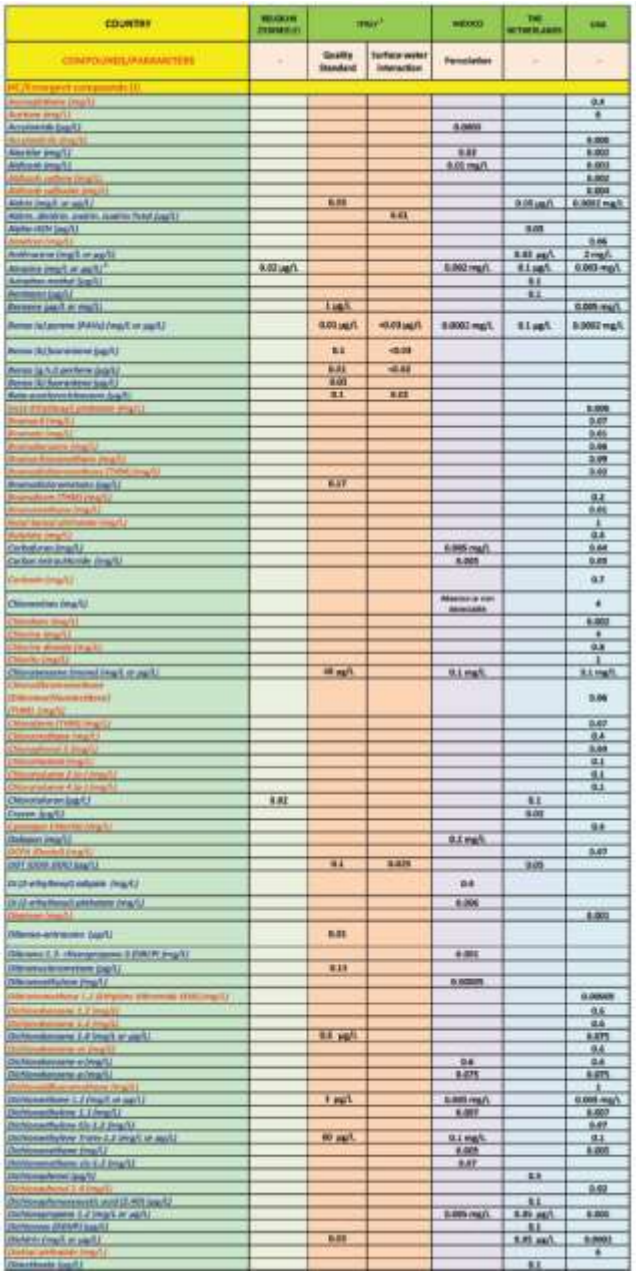


Number of parameters per legislation with water quality standards analysed

Results (2)

MACs in the world:

Maximum Allowable Concentrations (MACs) and ranges of tolerance



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

MACs comparison

Nitrate (NO_3^-) is the most frequently regulated parameter and is regulated in the standards from The Netherlands, Torreele (Belgium), Spain, Italy, Mexico and the State of Florida (USA).
Secondly, total nitrogen (TN) and total dissolved solids (TSS) are the most frequent parameters in the analysed quality standards.

e.g.:
-**TOC**: (x16): In Florida, TSS must be below 1 mg/l while in Mexico, 16 mg/l.
-**TSS**: In Florida, TSS must be below 5 mg/l while in Mexico, 150 mg/l (x10).
-**Total nitrogen**: highest MAC in Mexico (40 mg/l) and the lowest in California and Spain (10 mg/l).
-**Total phosphorus**: Mexican std. is the highest, 20 mg/l & Belgium has the lowest, 0.4 mg/l (x100).
-**Chloride:** limit in Mexico is 300 mg/l and the lowest value is found in California, with 120 mg/l (x2.5).
–**Sulphates:** Mexico shows the highest value again, 300 mg/l, and California the lowest (125 mg/l).
-**Turbidity:** highest MAC in Israel's standard (10 NTU) and the lowest and most strict in Spain (2 NTU for the direct injection case) (x5).

Regarding **(heavy) metal(oid)s**, Belgium and the Netherlands are the strictest. For example: **Zinc**: is 200 µg/l in Torreele and 65 µg/l in The Netherlands (x1/3) whilst California and Mexico propose a lower value of 5 mg/l (x77).

The most regulated heavy metals are arsenic, cadmium, lead and mercury, with their MACs reported in seven water quality standards.

In general, the Mexican legislation shows the most permissive MACs, whilst strictest are found in different standards, especially in Spain and California.

Results (3)

The most necessary parameters to analyze to satisfy most of the current regulations attending environmental impacts and risk assessment concerns:

Total 32 + spec. tech. decisions

PARAMETERS (MAR water)	EXPLANATION
E.coli	Ecotoxicological aspects. Demanded in most of the regulations (SAT-MAR)
Nematodes	Ecotoxicological aspects. Demanded in most of the regulations (SAT-MAR)
pH	Influence on REDOX conditions
Temperature	Environmental conditions. Product of solubility, stoichiometry
Conductivity	Parameter related to salinization and the total amount of compounds
Chemical Oxygen Demand (COD)	Specific parameter for water reuse, to be removed in case of natural water origin (SAT-MAR)
Biochemical Oxygen Demand in 5 days (BOD_5)	Specific parameter water reuse, to be removed in case of natural water origin (SAT MAR)
Total Dissolved oxygen (TDO)	Potential hyper-oxidation conditions and gas clogging creation in the receiving medium
Total Organic Carbon (TOC)	Indicator of biological clogging potential and buffer for chemical reactions
Total nitrogen (N)	Residual product after nitrogenised molecules breakdown, e.g. product of diffuse contamination decomposition
Total phosphorus (P)	Indicator of biological clogging potential and buffer for chemical reactions
Total suspended solids (TSS)	Parameter related to turbidity and demanded in most of the regulations
Total Dissolved Solids (TDS)	Parameter related to turbidity and demanded in most of the regulations
Turbidity	Parameter requested in most of the regulations
Ammonium (NH_4)	Residual product after nitrogenised molecules breakdown
Nitrates (NO_3^-)	Thick molecules usually trapped in the receiving mediums in which MAR projects take place
Sulphates (SO_4)	Macroconstituents, chemical attack on materials
Chloride	Macro, chemical attack on materials, salinity indicator
Bicarbonates	Parameter not requested in the regulations but fundamental for hydrochemical calculations
Sodium (Na)	Macro, chemical attack on materials, salinity indicator
Potassium (K)	Parameter not requested in the regulations but fundamental for hydrochemical calculations
Calcium (Ca)	Parameter not requested in the regulations but fundamental for hydrochemical calculations, hardness, etc.
Magnesium (Mg)	Parameter not requested in some regulations but fundamental for hydrochemical calculations, hardness, etc.
Boron (B)	Phytotoxic ion par excellence
Silica (Si)	Determines geochemical environments and biological/chemical reactions. Potential quartz precipitation
Arsenic (As)	Ecotoxicological ion par excellence
Iron (Fe)	Metal with high effect on physical, chemical and biological clogging generation
Manganese (Mn)	Physical, chemical, biological clogging determinant parameter
Chromium (Cr)	Physical, chemical, biological clogging determinant parameter. Requested in most of the regulations
Copper (Cu)	Special effect on crops. Usual spill from agro-industrial activities
Zinc (Zn)	Special effect on crops
Fats and oils	Specially for urban areas runoff and SAT-MAR (can be removed for natural river / rain water

Discussion

According to the different regulatory approaches reviewed, the **parameters in water quality standards regarding MAR depend on multiple factors**, such as:

- The **technologies** applied (multiple)
- The **environmental conditions** (with adaptation mechanisms to every climate, currently under climate change threats)
- The **final use** (e.g. drinking water must complain with higher quality standards than the water used for irrigation or cleaning).

It is also important to carry out:

Development of a common terminology

Consensus for rules and process to grant a permission, including the technical background for authorizations

Methodological approach and recommendations to achieve a "monitored recharge"

Need for a broader legal development

Recommendations

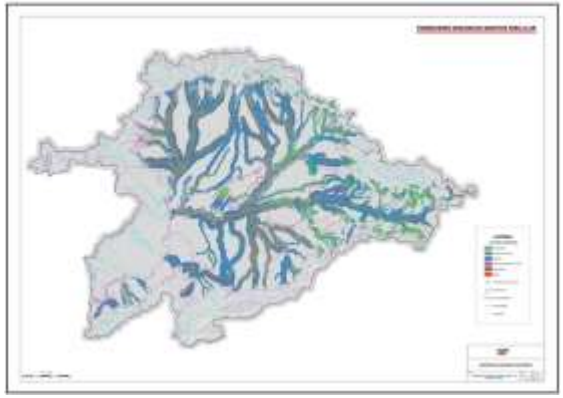
EVERY multi-barrier and multi-level **approach should be "aquifer-wide"** and consider:

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

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

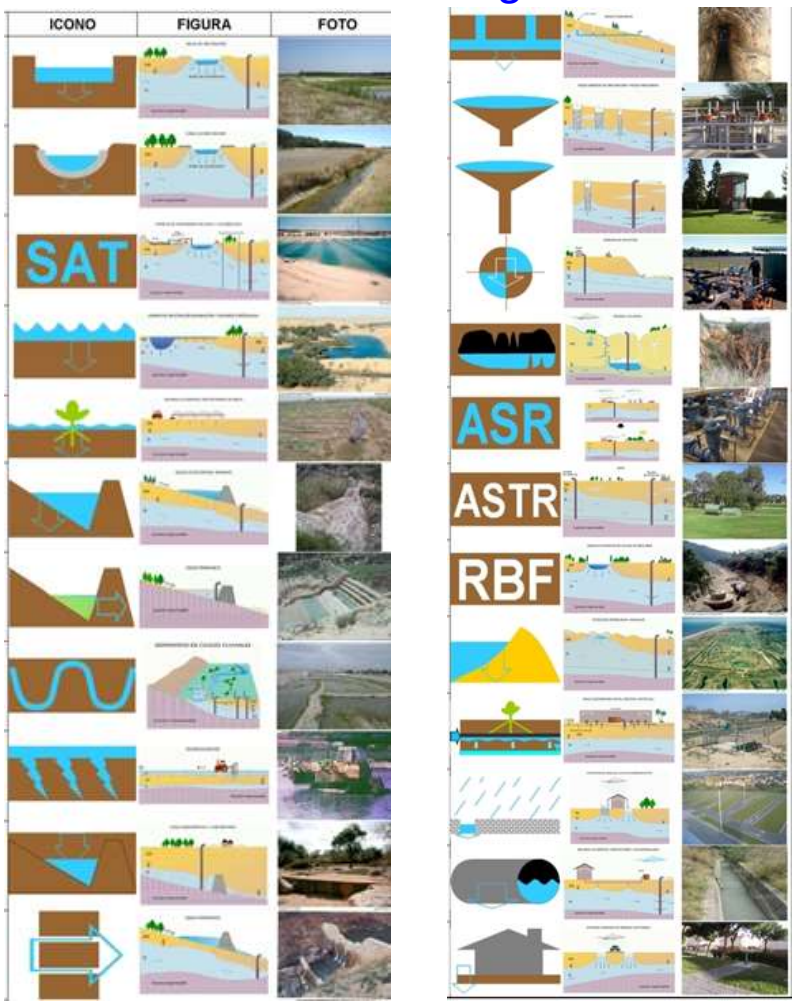
The final use (irrigation, drinking water…) and its feasibility in economic and politic terms

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



MAR map. Douro river basin

25 MAR technologies:



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

Conclusions

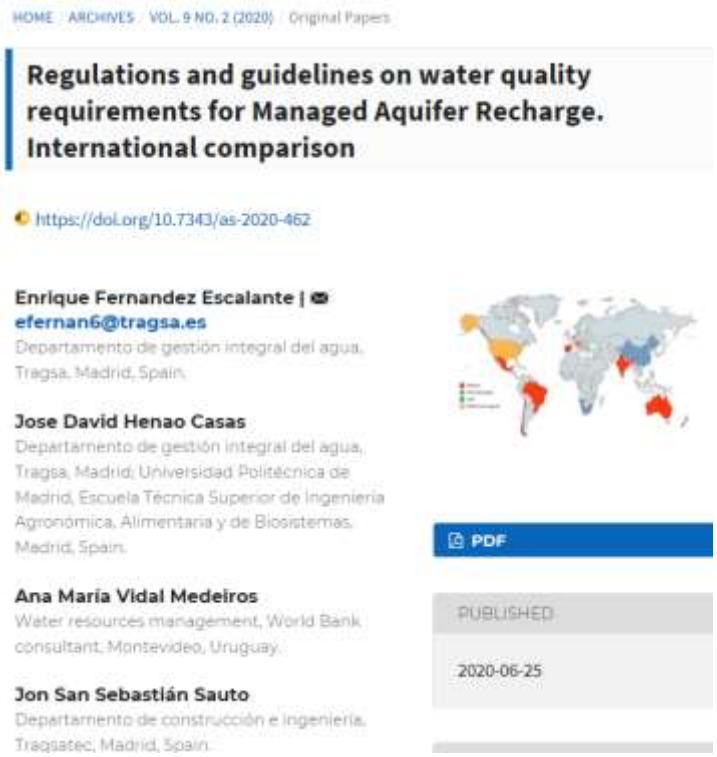
Distinction must be made depending on the type of recharge (either direct injection, percolation, infiltration through ponds, channels, wells…), **with different limits for each case**

Tailor-made water quality guidelines based on the aquifer and water source quality

Independent control and surveillance mechanisms are an asset

Finally, a risk assessment should be considered for each MAR policy.

To broaden this info:



HOME ARCHIVES VOL. 9 NO. 2 (2020) Original Papers

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

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IAH-MAR or Managing Aquifer Recharge Commission

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

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Managed Aquifer Recharge

Managed aquifer 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.

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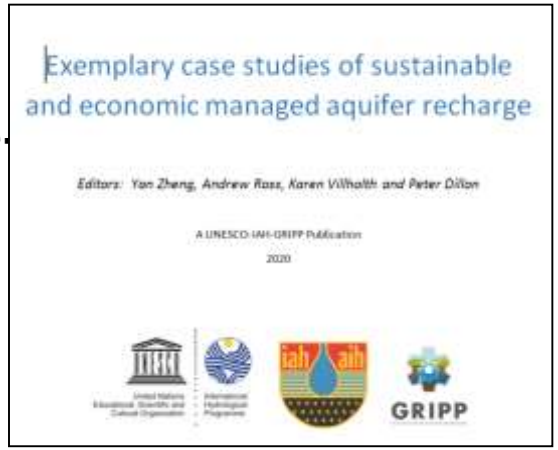

Madrid, 2020 October 30th

Thank you very much