DEMEAU

Demonstration of promising technologies to address emerging pollutants in water and waste water

Managing Aquifer Recharge

Final Project meeting

17th – 18th June, Dübendorf

C. Sprenger (KWB), M. Hernandez (CETaqua), E. Vilanova (AMPHOS21), S. Hannappel (HYDOR), B. de la Loma González (KWR), J. Plattner (FHNW)

This project has received funding from the European Union's Seventh Programme for Research, Technological Development and Demonstration under Grant Agreement no. 308339.

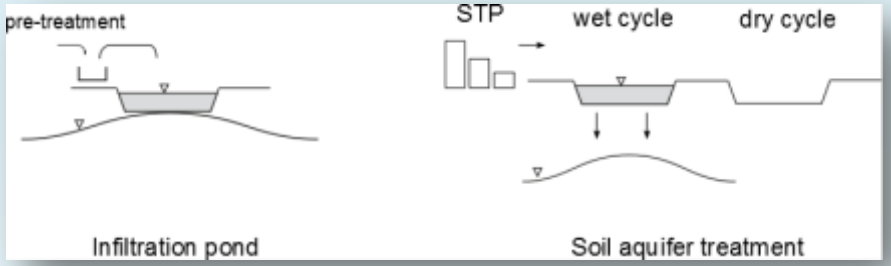
INDEX

Overall objective

To support the implementation and optimization of MAR schemes in Europe in compliance with the European Union Water Directives

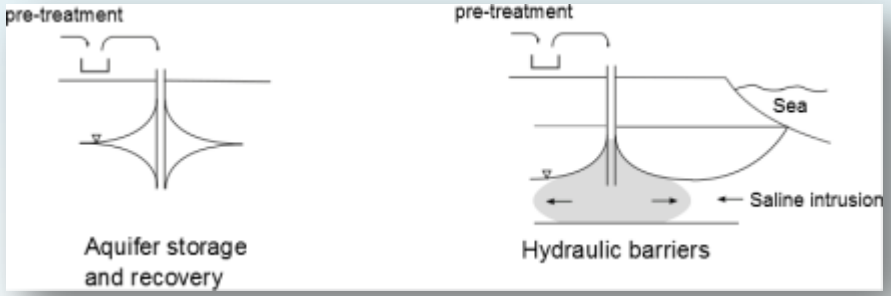
Infiltration pond for drinking water production in Berlin (D), operated by Berliner Wasser Betriebe

MAR classification



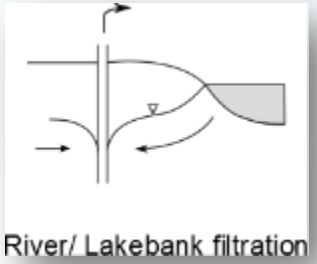
Surface Spreading

- Gravitational recharge by structures at or near to surface level (incl. shafts, pits, reverse drainage etc.)



Well Injection

- Injection of water into a borehole (incl. ASR/ASTR)



Induced Bank Filtration

- Infiltration of surface water induced by pumping from nearby well

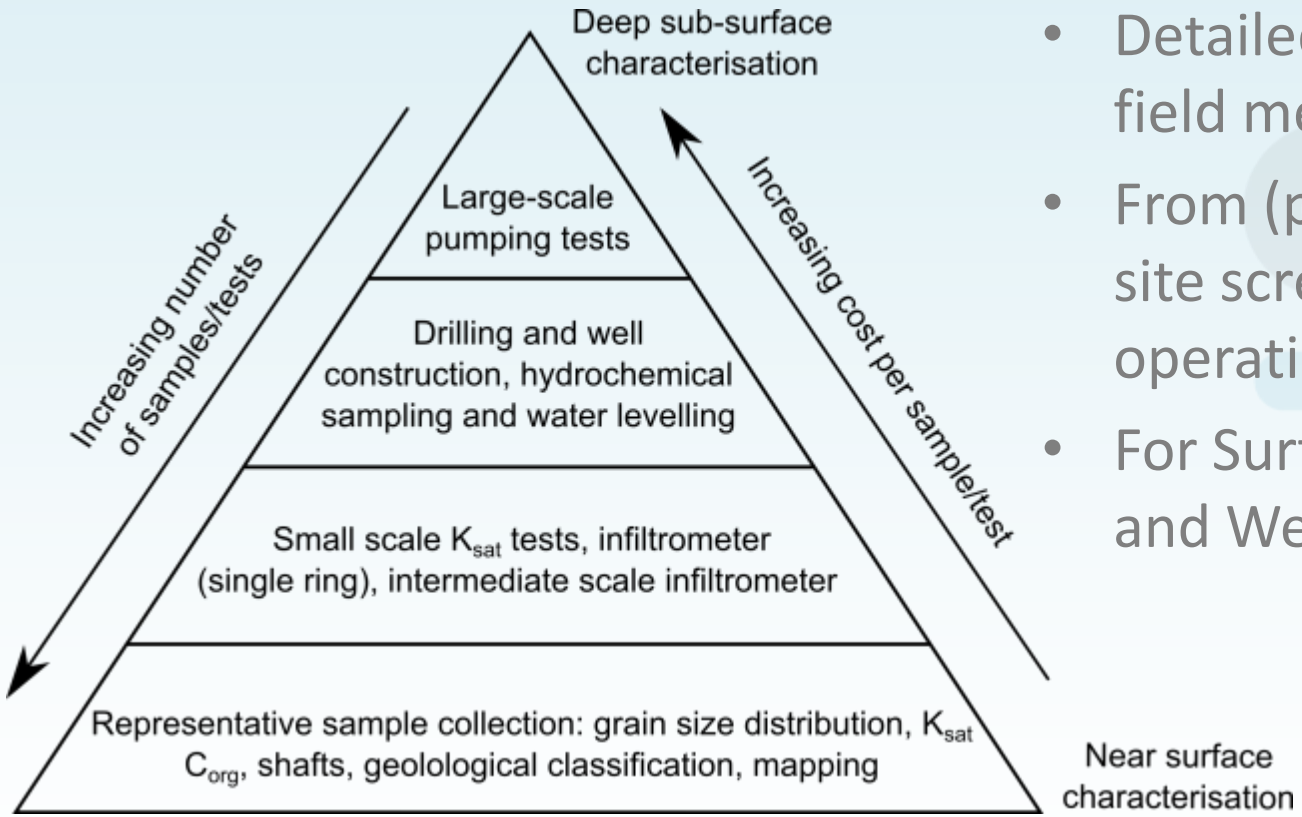
Example of pre-requisites

Parameter	Criteria	Suitability assessment
Target aquifer permeability, k_f (m/s)	$< 10^{-6}$	Very low, limited suitability
	$10^{-6} – 10^{-5}$	Low, limited suitable
	$10^{-5} – 10^{-4}$	Medium, suitable
	$10^{-4} – 10^{-3}$	High, suitable
	$>10^{-3}$	Very high, suitable
Saturated thickness in target aquifer (m)	<10	Thin, high potential recovery rate
	10-50	Medium, medium potential recovery rates
	>50	Thick, low potential recovery rate

from Deliverable 12.2 (2015)

- Objective criteria for 9 essential hydrogeological parameter
- Unsaturated zone
- Saturated Zone
- Valid for surface spreading and well injection

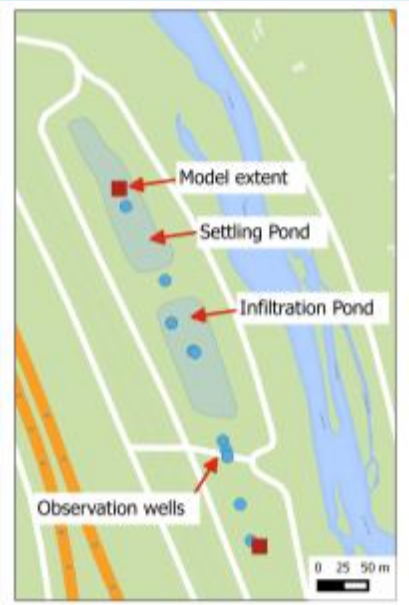
Investigation procedure and methods



- Detailed description of field methods
- From (pre-)feasibility to site screening to operational design
- For Surface spreading and Well injection

Taken from Deliverable 12.2 (2015)

Calculation of travel time by heat tracer



Numerical engine (VS2DI)

- Saturated and unsaturated flow
- Heat and solute transport

GIS data (QGIS)

- Pond extent
- Well design

Calibration

- Water levels
- Temperature

Data input

- Time series (water level, temperature, water volume etc.)
- Hydrogeology

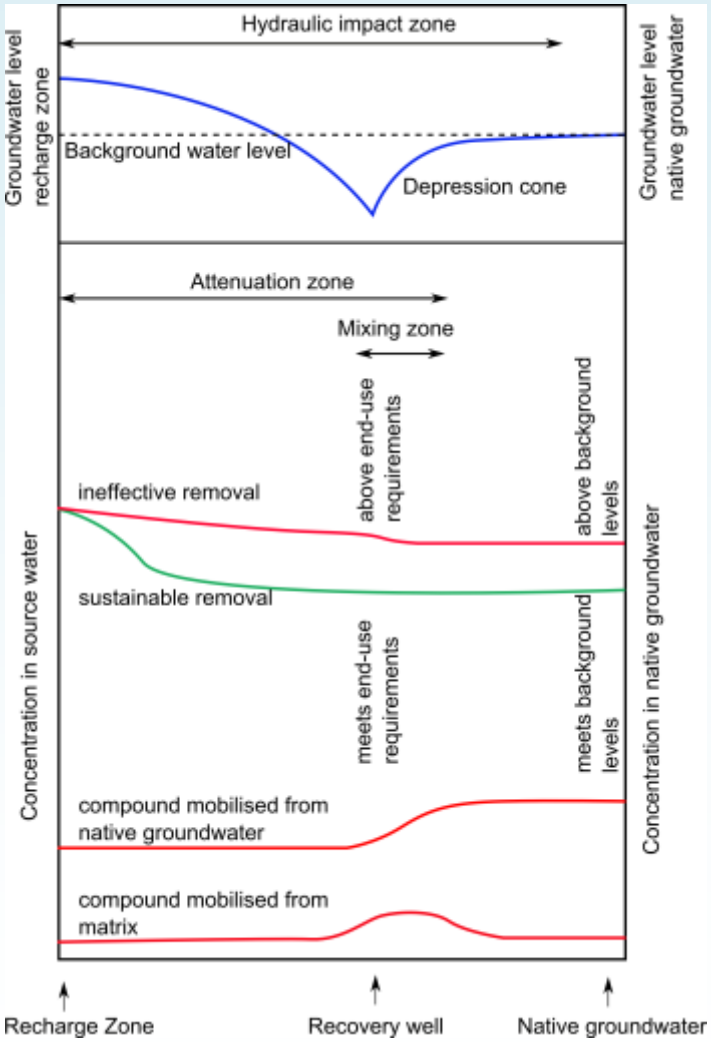
Reporting

Monitoring Well	Dominant travel time (day)	Share of infiltrate (%)
BSV-2	5	100
BSV-5	5.1	100
BSV-3	6.8	100
BSV-6_3	7.8	99
BSV-10	9.6	98
BSV-9	10.9	95
BSV-6_1	13.4	88

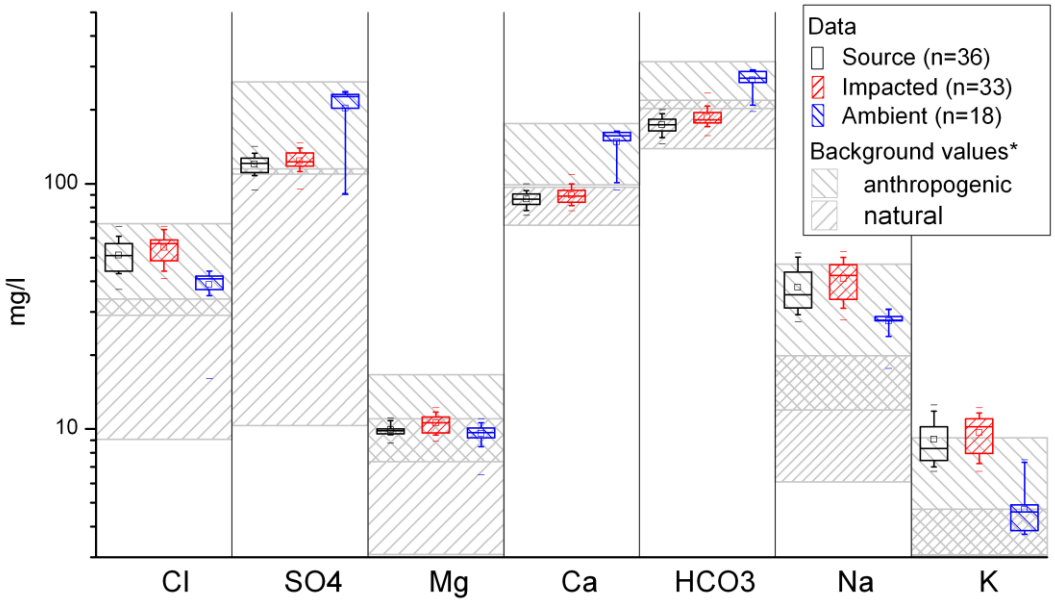
Tool Box: http://demeau-fp7.eu/toolbox

IMPACT ASSESSMENT ATTENUATION

Conceptual Understanding



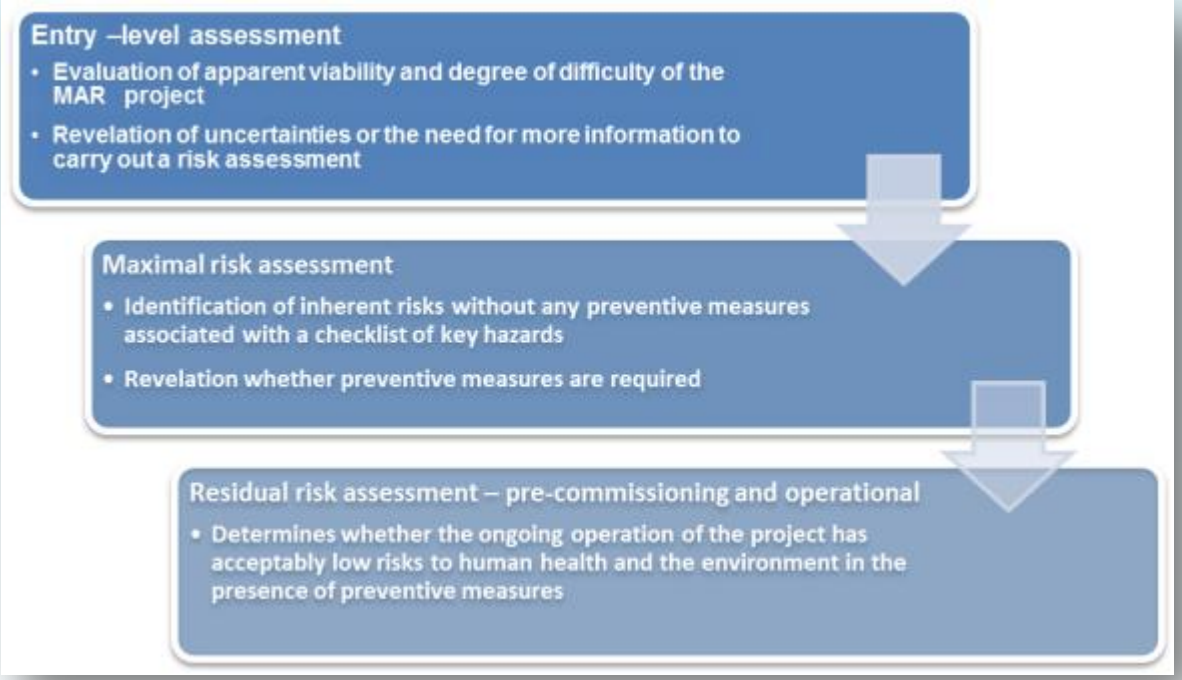
Case study: Infiltration Pond Berlin Tegel



* from FUGRO and HYDOR (2002)

Taken from Deliverable 11.2 (2015)

Managing health and environmental risks – The Australian approach



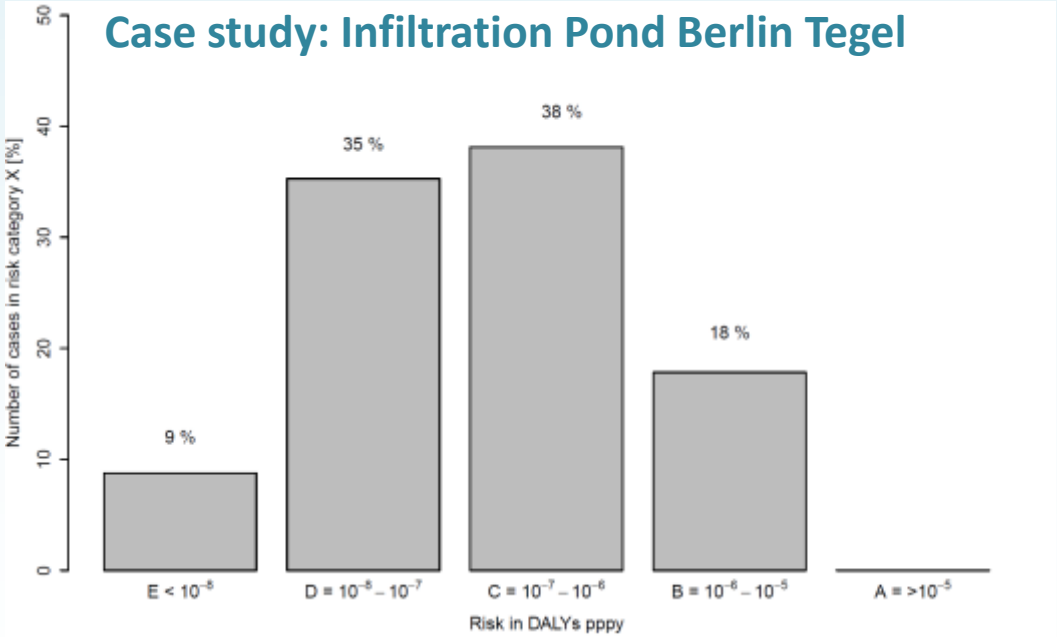
(NRMMC-EPHC-NHMRC 2009)

- The only risk assessment approach for MAR worldwide
- Based on different levels of assessment, questionnaires, simple analytical models for flow and transport
- Applied for infiltration pond in Berlin-Tegel and well injection in Castellon

RISK ASSESSMENT ROTAVIRUS REMOVAL

Human health disease burden

- expressed as 1 additional µDALY per person per year (pppy) recommended by the WHO
- aquifer treatment barrier was assessed for its log(10) removal capacity

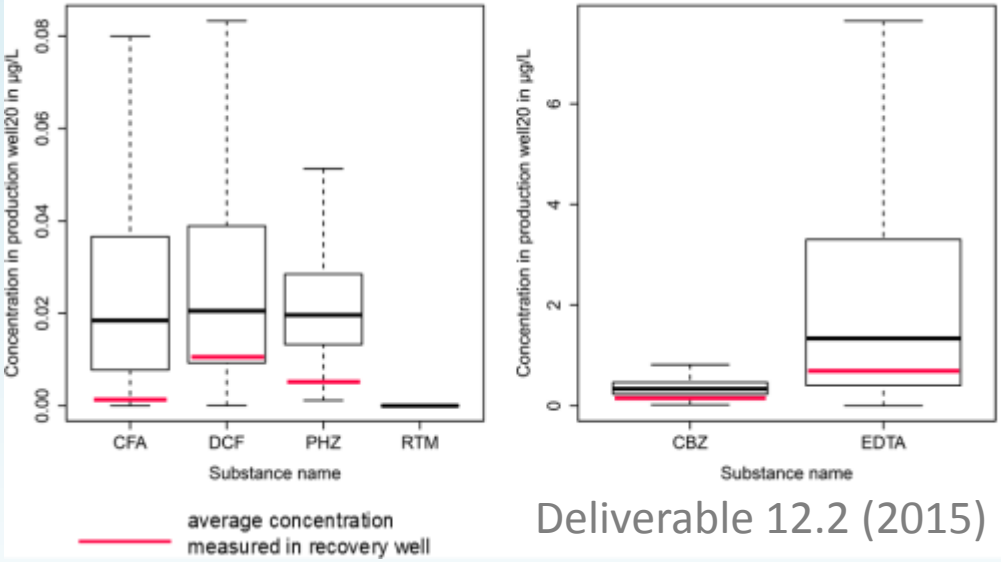


Class	Additional 1 µDALY
A	> 10 fold excess
B	1-10 fold excess
C	< 10 times
D	< 100 times
E	< 1000 times

82% probability below 1µDALY at Berlin-Tegel

RISK ASSESSMENT TRACE ORGANICS

Case study: Infiltration Pond Berlin-Tegel



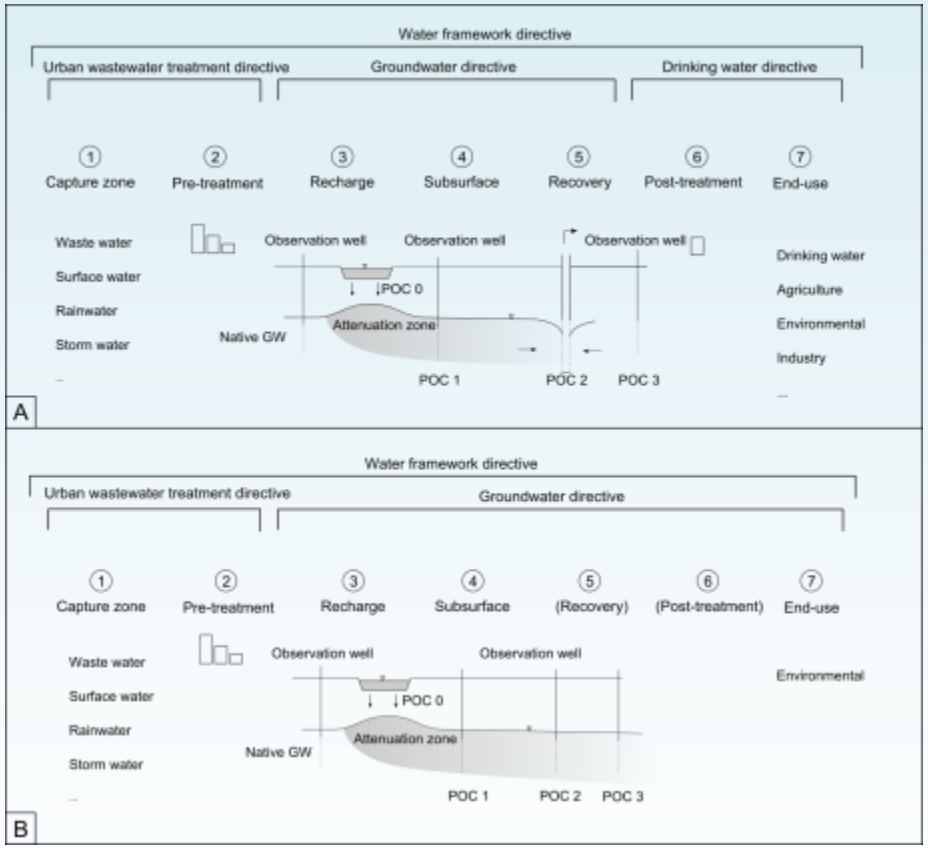
Deliverable 12.2 (2015)

Assumptions:

- Chemical specific retardation (Log D)
- First order decay (half life) and dilution

- kinetic order of biotransformation for many organic chemicals is not known
- laboratory attenuation studies are unlikely to simulate the microbial community that develops in an aquifer

In this case compliance with Drinking water thresholds or Health-oriented guidance values



from Deliverable 12.1 (2014)

- Deconstruction of MAR in 7 functional elements

Groundwater Directive (GWD)

- Recharge water quality should meet the end-use requirements beyond a defined attenuation zone
- Points of compliance (POC) to meet GWD “good ecological and chemical status”

CONCLUSIONS & PERSPECTIVES

MAR in Europe

- MAR plays an important role in the European water sector (drinking water but also environmental benefits)
- Potential for MAR in the Mediteranean region

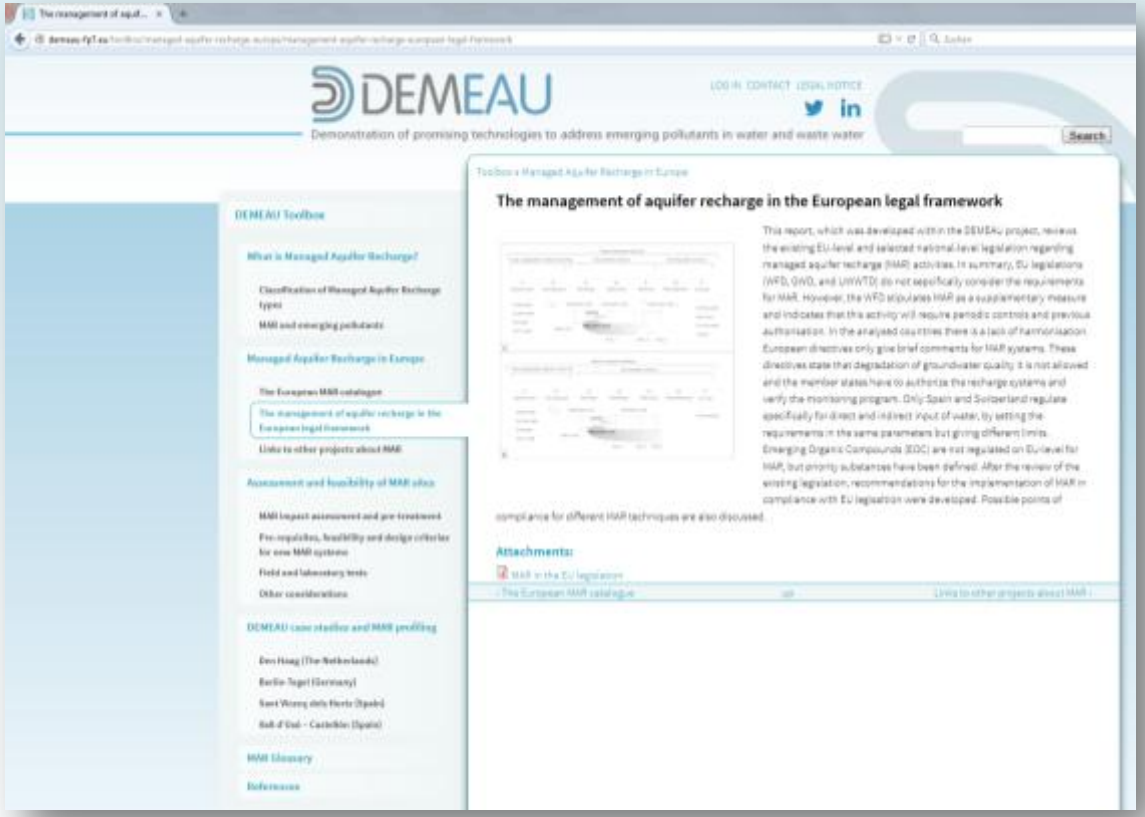
Risk assessment

- Australian guidelines constitute a robust basis for risk management for MAR schemes in the EU

Towards authorisation

- Integration of the attenuation zone to account for natural removal processes
- Monitoring concept (points of compliance) and aquifer background levels

Please visit the MAR tool box



- Pre-treatment options
- Tracers for MAR
- DEMEAU case studies
- R-software tools
- Long-term performance evaluation
- MAR profiling
- And more….

http://demeau-fp7.eu/toolbox

Thanks to all contributing partners!

AMPHOS 21

eco logic

eawag aquatic research

HYDOR

CETaqua WATER TECHNOLOGY center

BDS BioDetection Systems

KWR Watercycle Research Institute

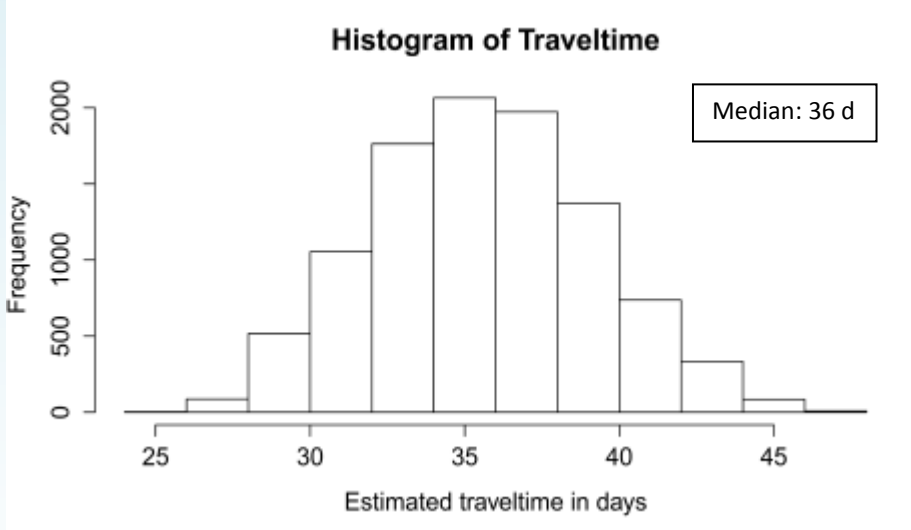
IWW

KOMPETENZZENTRUM Wasser Berlin

n|w University of Applied Sciences and Arts Northwestern Switzerland School of Life Sciences

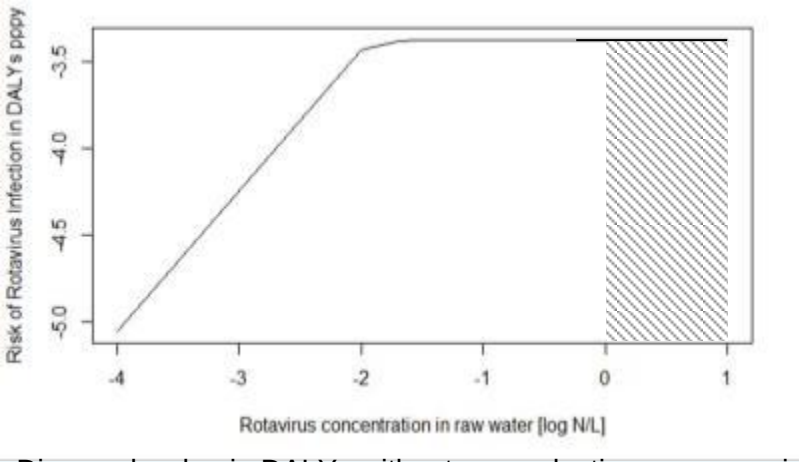
This project has received funding from the European Union's Seventh Programme for Research, Technological Development and Demonstration under Grant Agreement no. 308339.

Case study: Infiltration Pond Berlin Tegel



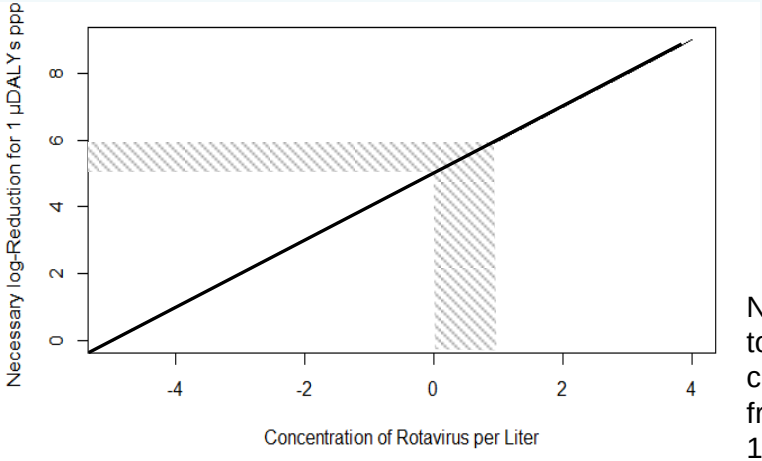
Assumptions:

Parameter	Value
Aquifer thickness (m)	30
Porosity of the aquifer (%)	20-30
Distance between point of infiltration and recovery well (m)	100
Average pumping rate of well 20 (m^3/d)	1920-2400
Minimum depth to the mounded water table beneath the infiltration basin or gallery (m) (not yet available)	0.5-6
Saturated hydraulic conductivity (m/s)	1.5×10^{-4}-1.1×10^{-3}



Disease burden in DALYs without any reduction measures in place. Assumptions (1L drinking water consumption per day, disease per infection ratio (0.5), susceptible fraction (6%), dose response parameters for Rotavirus from (Haas et al. 1999), severity factor ($1.4*10^{-3}$ DALYs/case of disease)).

Treatment	Log removal (LRV)	Remarks/assumption
Subsurface passage **(assumption: effectiveness comparable bank filtration for microbiological parameters)**	2.1-8.3	Depending of the residence time in subsurface. Assumption: 4-6 LRV
Rapid sand filtration	0-3.5	Depends on filter media and coagulation pre-treatment: Assumption 1-2 LRV



Number of log removal (LRV) required to be in compliance with a tolerable level of risk of 1 µDALY pppy. Assumptions: 1L drinking water consumption per day, disease per infection ratio (0.5), susceptible fraction (6%), dose response parameters for Rotavirus from ({Haas, 1999 }).

Impact assessment of MAR

General site description

location, operational scale, infiltration rates,
infiltrated volumes, source water type, pre-/post-treatment

↓

Hydraulic characterisation

general flow field, share of recharged water,
recovery rate, infiltration cycles, hydraulic impact zone

↓

Comparison of groundwater background values with ambient groundwater

natural background level and/or
anthropogenic background levels from

i) historical data ii) pre-selection or iii) component separation

comparison of background levels with source/impacted
and ambient groundwater
e.g. major ions, inorganic traces, nutrients, microbiology,
organic trace compounds

- Characterization of MAR flow regime
  - General flow field, travel times, hydraulic impact zone
- Water quality impact assessment
  - Reliability check (ion balances)
  - Comparison of water quality data with background values

Natural Background Levels

Aquifer typology

only if limited data of groundwater chemistry is available

Pauwells et al. 2006

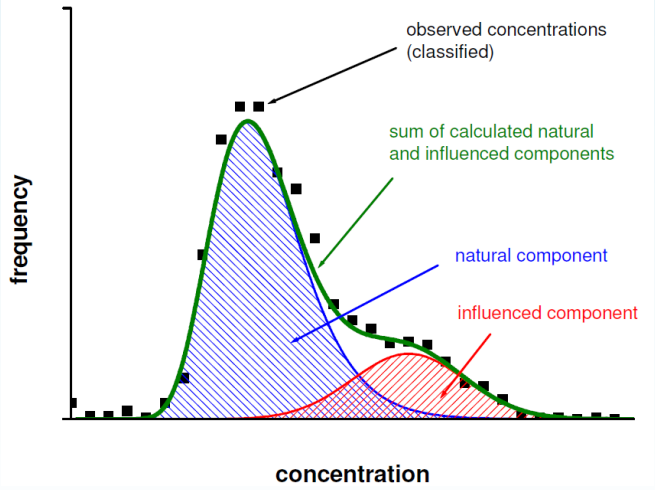
Pre-selection method

certain chemical compounds can be used as tracers indicating exclusively anthropogenic influence

Müller et al. 2006

Component separation

scientific sound but data intensive and applicable by experts only



Kunkel et al. 2004

EU funded project BRIDGE –
Background cRiteria for the IDentification of Groundwater thrEsholds
http://nfp-at.eionet.eu.int/irc/eionet-circle/bridge/info/data/en/index.htm