Policy letter

Recommendations from AQUAREHAB research related to

Full Integration of Groundwater in Water Management at Basin Level

1 INTRODUCTION

Water managers have to make decisions on the implementation of measures to improve the status of the aquatic ecosystem. The available information on innovative rehabilitation technologies, and more specifically groundwater remediation technologies, is complex and therefore difficult to incorporate in programmes of measures. Challenges related to the implementation of groundwater remediation technologies at the river basin or groundwater body scale are (1) the upscaling from field to catchment scale, (2) the interaction between groundwater and surface water, (3) the time delay between action and effect due to the attenuation processes, and (4) the assessment of the effects of multiple measures within one catchment. Often technologies act on just a specific set of chemicals whereas multiple chemicals end up in the groundwater or surface water and may cause adverse effects to ecology. Ecological effects of mixtures of chemicals arriving at different time periods in the catchment are difficult to assess.

The policy context for water management in Europe is largely defined by the European Water Framework Directive (WFD). The WFD explicitly mentions the concept of a water body as the preferred scale, which can be quite detailed, depending on the Member State and the specific river basin. Member States need to report the amount of water bodies reaching good status now and in the future. The WFD requires that these plans include cost-effective programmes of measures. How to identify which measures are cost-effective is an important target for a water management decision support system (DSS).

2 OBSERVATION MADE WITHIN AQUAREHAB

A specific goal of AQUAREHAB was to link impacts of the considered (groundwater) rehabilitation technologies to the river basin management. As illustrated in Figure 1, fluxes of pollutants were envisioned to make the connection.

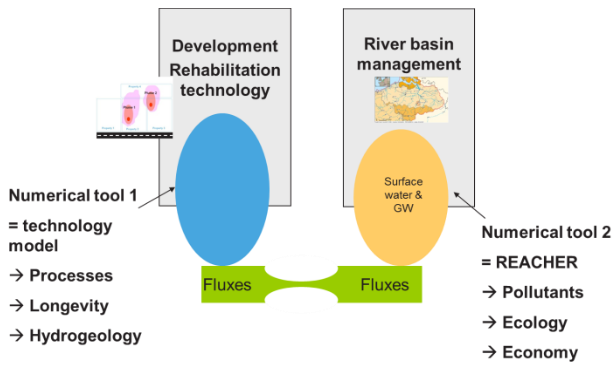

Figure 1: Integration of estimated impacts of groundwater remediation technologies into river basin management.

However, quite early in the project it was sensed that this may be much more challenging than expected. AQUAREHAB is a multidisciplinary project where results of different research aspects (technology, hydrology, modelling, economics, ecology, …) needed to be integrated for technology modelling purposes as well as for elaborating a prototype of a new decision support tool for water managers. This required intensive interactions between project partners focussing on groundwater remediation and partners active in elaborating tools for water management. These two research domains were found to be two distinct worlds that were driven by different points of view, separate legislations and a different language (Figure 2). Interactions seemed to be limited and led to confusing communications as the same words often have a different meaning in the groundwater remediation world and river basin management domain. These observations were not restricted to the scientific community but also relevant to a certain degree for the associated stakeholders and authorities. This observed lack of interaction was the trigger to investigate more in detail the underlying causes. Efforts from both sides were made aiming to nevertheless to bridge the divide between groundwater remediation and river basin management (Figure 2).

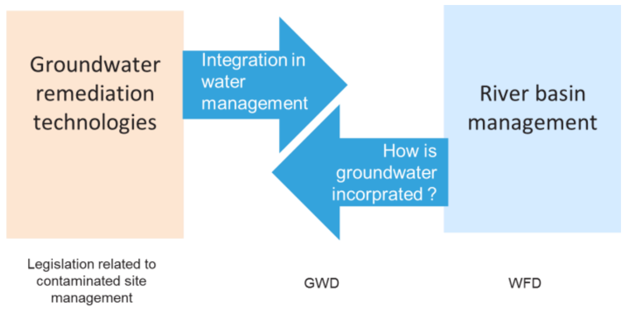

Figure 2: Efforts made in two directions to integrate impacts of groundwater remediation technologies in river basin based water management (GWD: Groundwater directive; WFD: Water framework directive).

It was concluded that river basin management up to now has mainly focused on the impacts on surface water bodies and that the groundwater compartment is only partially covered. The full integration of groundwater into river basin management, not only as path but also as receptor, including local scale aspects, would be a step forward. However, this is not obvious because of differences in scale, dynamics, pollutant types and legislation. The following special efforts were made to bridge the gap between groundwater management related to contaminated sites at the site- or parcel-scale (driven by legislation confined to land ownership) and water management at the river basin scale or groundwater body scale (driven by the WFD).

A first important aspect was to make people working in the water management area and people focussing on groundwater management aware of this gap, and bring them in contact with each other for discussions. This proved to be very challenging, as it was like bringing together two nearly completely different worlds. In September 2012, AQUAREHAB and the WaterDiss2.0 project organised a Policy (implementation) session in Barcelona aiming to match the needs of policy makers and practitioners to the new solutions provided by research projects in order to meet the objectives set out in the Water Framework Directive and related directives. One central issue for the groundwater management discussion was that currently the integration of groundwater management and remediation in 'water management' does not seem to be fully accomplished by EU policy.

Further, it was decided to elaborate not only a prototype of a general water management tool (REACHER), but also a tool for groundwater management (REACHER-local). REACHER local is a tool that covers the gap between river basin management and groundwater remediation technologies (Figure 3).

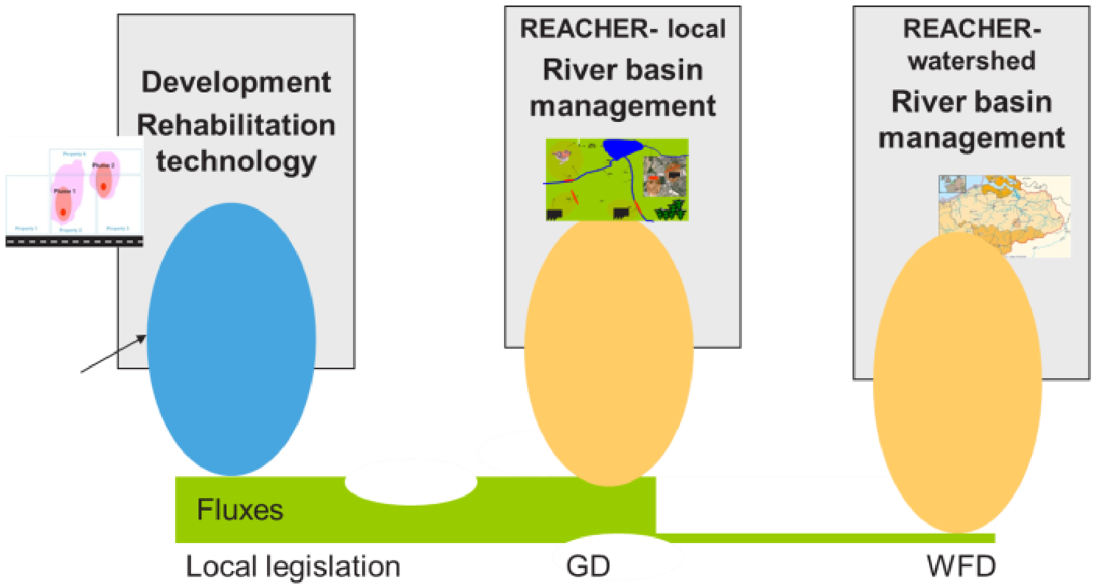

Figure 3: Adapted scheme to integrate impacts of groundwater technologies in a regional river basin management via pollutant fluxes, while the link with watershed management is more difficult to link via fluxes.

3 Recommendations to Policy Makers & Authorities

- Groundwater may require a different approach in river basin management in comparison with surface water, but cannot be neglected when evaluating the general water quality.
- Both approaches need to interact and it is preferable to combine them in an integrated water management approach;
- Groundwater quality management may be preferred at a scale smaller than the groundwater-body scale, considering primarily 'local' groundwater fluxes;
- Groundwater that is not discharged immediately into surface water and that is not included in currently defined drinking water catchment areas, is also to be considered as a receptor (i.e. also a reserve of fresh water) and not only as a path between source and surface water as receptor;
- The quality assessment parameters for groundwater according the current river basin management approach are currently limited to quantification of a limited set of listed pollutants, while no approaches are described/available to evaluate the groundwater ecology. Therefore, the currently available data (which may be limited to pollutant concentration data for a few wells in an area of up to 6000 km²) may not be a reliable indicator for the groundwater quality in this area. Recommendations related to the groundwater quality assessment include :

→ The pollutants that are considered in the integrated water management approach should be extended with compounds relevant for groundwater – even if they may not be that relevant for surface waters (such as volatile compounds);

→ In respect to groundwater pollution monitoring, it is recommended to use a denser net of monitoring wells, but to sample less frequently. This recommendation is based on the less dynamic character of groundwater in comparison to surface water.

→ It may be considered to identify additional parameters (besides chemical analyses) to evaluate the groundwater quality. A possibility may be to identify and define micro-organisms relevant for the (anaerobic) subsurface, to complement the quality evaluation with an ecological parameter. These micro-organisms could also be useful to evaluate the impact of remediation agents in the subsurface.

- The groundwater monitoring network in river basin management is currently installed mainly to evaluate diffuse pollution originating from agriculture. It may be worth to install addition wells or to consider the use of the extensive 'Site management' data bases on groundwater pollutants to evaluate the global groundwater quality.

- Although data are available for many areas, there is no global inventory of the groundwater related 'local problems in Europe or member states'. A reason may be that this type of information can be sensitive (depreciation of land, …) and is not always publicly available. It is recommended to identify more precisely the existing barriers for developing such inventories, and to invest efforts to lower these barriers.

- Harmonisation of standards (such as groundwater intervention values) and legislation concerning risk assessment and management of contaminated sites/areas on European level would be a step forward. It avoids that each country/region has to develop (re-invent) its own system and will give a less confusing message to polluters & site owners. Nowadays regional differences in standards do have economic implications.

4 MOTIVATIONS FOR RECOMMENDATIONS

Background AQUAREHAB project

The AQUAREHAB project was financed within the FP7 Call "rehabilitation technologies for degraded water systems presenting quantity and quality problem". The related call text explicitly mentioned that the outcomes of the project within this call should help decisions makers as described below.

Expected impact formulated for call ENV2008.3.1.1.1

- Current rehabilitation technologies are frequently limited by the fact of not addressing the water system as a whole.
- The project should contribute to more reliable, ecologically engineered and cost-effective technological solutions, which also take into account the impacts of climate change on water bodies, mitigation and adaptation policies.
- It should also help decision makers
  - to assess the immediate and long-term effectiveness of restoration actions and
  - to design appropriate environmental planning and optimal investment strategies at regional level, in line with the requirements of various water related EU policies.

The AQUAREHAB project started 1st May 2009 with a multi-disciplinary team comprising of 19 project partners. Within the project, different innovative rehabilitation technologies for soil, groundwater and surface water were developed to cope with a number of priority contaminants (nitrates, pesticides, chlorinated compounds, aromatic compounds, mixed pollutions…) within heavily degraded water systems. Methods were developed to determine the (long-term) impact of the innovative rehabilitation technologies on the reduction of the influx of these pollutants, of which some are on the list of priority substances, towards receptors or water bodies. Possible connections and barriers between the innovative technologies and river basin management tools were evaluated. Two target deliverables of the project were (1) generic guidelines for the use & design of technologies and (2) a generic river basin management tool that integrates multiple measures with ecological and economic impact assessments of the whole water system.

Importance of water

Water is one of the most important substances on earth. All plants and animals must have water to survive. If there was no water there would be no life on earth. Apart from drinking it to survive, people have many other uses for water, such as cooking, washing & cleaning, recreation, … . Water is also essential for the healthy growth of farm crops and farm stock, and is used in the manufacture of many products. In contrast to salt water, it is mostly only the fresh water that can be used.

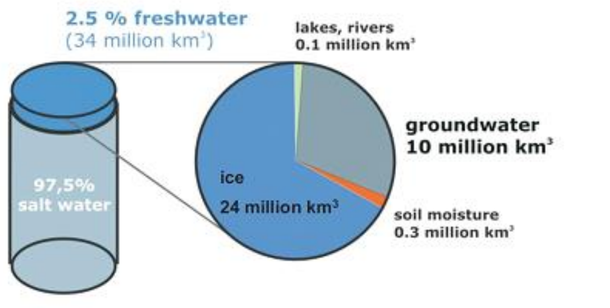

Figure 4. Water on earth (BGR, 2008)

A large amount of water is present on earth (1.4 billion km^3), which comprises mostly salt water (Figure 4). Only 2.5% of the total available water is fresh water. The major part of this fresh water is stored as ice (~ 70%) and groundwater (~ 30%), while surface water and soil moisture together represent less than 0.01%. The presented numbers emphasize on the importance of groundwater as a 'reserve' source of fresh water now and in the future. For this reason, the quality of the groundwater cannot be ignored and all possible efforts need to be made (1) to prevent pollution of groundwater and (2) to prevent spreading of contaminants that are already present in the groundwater and subsurface.

From an economic point of view, groundwater pollution has different impacts depending on land use, use of groundwater and the actions from the ground water users. Economic damages considered within the AQUAREHAB project (DL8.2) comprise:

- Additional costs related to the treatment of groundwater before use. Users of groundwater continue to use this groundwater, but take additional steps and costs to clean this groundwater before use for residential or industrial purposes.
- Additional costs for former groundwater users, who switch to drinking water (for residential or industrial use) or import water from other areas (for producers of drinking water).
- Loss of property value for land owners. If groundwater is polluted, this area becomes less attractive to live, and this loss is reflected in the market prices for residential buildings. This is a proxy for the loss of (potential) use of groundwater, as reflected in the real estate market. These costs are to be borne by the land-owners.
- Costs of health impacts for people living or working in a building with increased indoor pollution due to groundwater pollution. These are welfare losses for these users of the land .
- Preservation value: Loss of opportunities for potential future groundwater use, for all potential future users.
- Damages to ecosystems that depend on the contaminated groundwater and connected surface water.

Groundwater approached from different angles

At the European level, groundwater management is part of the WFD (2000) as this Directive aims for 'good status' for all ground and surface waters (rivers, lakes, transitional waters, and coastal waters) in the EU. However, the Directive was initiated with a focus on surface water as is reflected in: (1) the type of priority pollutants that have been listed; and, (2) the status-evaluation criteria that have only been worked out in detail for surface water.

Water Framework Directive (WFD)
The WFD aims for 'good status' for all ground and surface water (rivers, lakes, transitional waters, and coastal waters) in the EU.

For surface water: the ecological and chemical status is assessed according to the following criteria:

- Biological quality (fish, benthic invertebrates, aquatic flora)
- Hydromorphological quality such as river bank structure, river continuity or substrate of the river bed
- Physical-chemical quality such as temperature, oxygenation and nutrient conditions
- Chemical quality that refers to environmental quality standards for river basin specific pollutants. These standards specify maximum concentrations for specific water pollutants. If even one such concentration is exceeded, the water body will not be classed as having a "good ecological status".

The Water Framework Directive stipulates that groundwater must achieve "good quantitative status" and "good chemical status" (i.e. not polluted) by 2015. Groundwater bodies are classified as either "good" or "poor".

An important aspect of the Water Framework Directive is the introduction of (potentially trans-boundary) River Basin Districts as the basis for water management. Towards the groundwater, groundwater bodies are defined within each river basin district. In total, about 13,300 groundwater bodies have been delineated in the EU with an average size of around 300 km², ranging from 1 to 5,827 km² (Scheidleder & Bogaert, 2013).

As the WFD was less elaborated for groundwater, a separate Groundwater Directive (GWD, 2006/118/EC2) was established to prevent and control groundwater pollution.

Groundwater Directive (GWD)
The Groundwater Directive complements the Water Framework Directive (WFD). It requires:

- groundwater quality standards to be established by the end of 2008;
- pollution trend studies to be carried out by using existing data and data which is mandatory by the WFD (referred to as "baseline level" data obtained in 2007-2008);
- pollution trends to be reversed so that environmental objectives are achieved by 2015 by using the measures set out in the WFD;
- measures to prevent or limit inputs of pollutants into groundwater to be operational so that WFD environmental objectives can be achieved by 2015;
- reviews of technical provisions of the directive to be carried out in 2013 and every six years thereafter;
- Compliance with good chemical status criteria (based on EU standards of nitrates and pesticides and on threshold values established by Member States).

To reach the aims of the Groundwater Directive, a number of requirements have been defined (see above), including the establishment of quality criteria. These include groundwater quality standards set at Community level (Annex I of GWD, Figure 6) and threshold values.

Threshold values are quality standards that have to be set by Member States for pollutants causing a risk of not meeting WFD requirements. The minimum list of pollutants for which thresholds need to be set comprises: (1) priority substances listed for surface water defined in WFD Annex I; and also includes (2) arsenic, cadmium, lead, mercury, ammonium, chloride, sulphate, trichloroethylene, tetrachloroethylene, and conductivity (salinity).

Since 1990 different pieces of legislation have been designed to protect groundwater against pollution and deterioration (Figure 5), comprising the Nitrates Directive (96/676), the Urban Wastewater Treatment Directive (91/271/EEC), the Biocide Directive (98/8/EC) and the Landfill Directive (99/31/EC). These legislations are directly linked to the Water Framework Directive and the Groundwater Directive, and it is stated that 'the concept of groundwater protection is now fully integrated into the basic measures of the Water Framework Directive'. The groundwater standards considered at river basin scale (Figure 6) are based on the different EU environmental legislation.

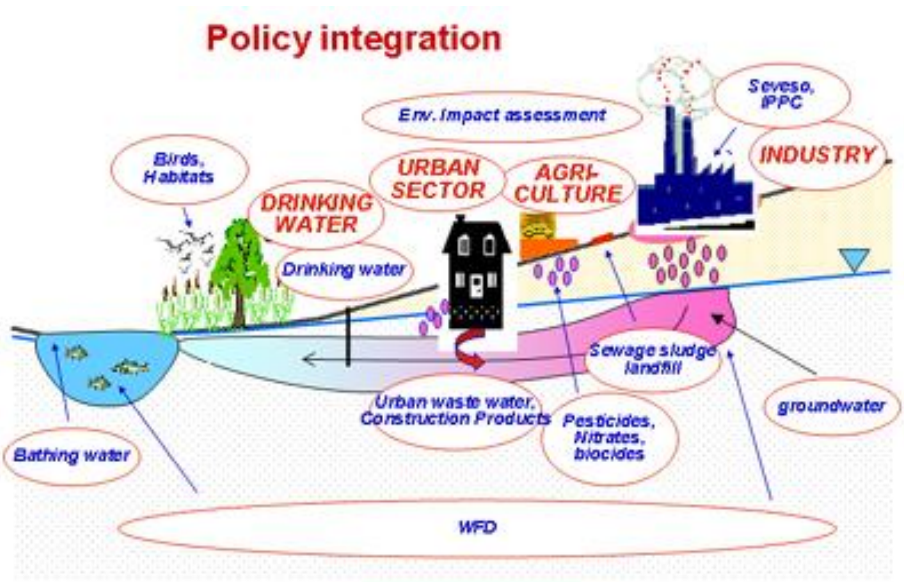

Figure 5: Integration of the various European legal instruments.

So at the European level, from a WFD perspective, the quality of the groundwater is evaluated via a uniform approach with the focus on the impact on surface water, discharge points and diffuse pollution. For the quantitative aspects water abstraction points and discharge points are considered. The quality evaluation is made at the groundwater body scale.

Remediation of groundwater, however, is a local and rather site specific action that is driven by 'site management' legislation at (sub)member state level. Although not standardized across Europe, the general approach comprises: (1) screening of groundwater qualities at sites with potential pollution; (2) more in depth site investigations; (3) preparation of a remediation plan; (4) implementation of remediation measures; (5) monitoring & adjustments of the treatment; and (6) site closure. Evaluation of the groundwater quality is mainly based on a list of intervention values defined for specific pollutants. The type of pollution on the list, as well as the intervention limits, do differ significantly between countries/regions (Provoost et al., 2006). This causes geographical differences in the economic impacts of remediating contaminated groundwater.

As an example, the pollutants considered in the Flanders region of Belgium are listed in Table 1 together with risk based intervention values. This list is significantly different from the compounds considered at the groundwater body scale (Figure 6). Table 2 illustrates differences between countries/regions in respect to: (1) the list of compounds considered; and, (2) the limits set for further investigations.

GROUNDWATER QUALITY STANDARDS

1. For the purposes of assessing groundwater chemical status in accordance with Article 4, the following groundwater quality standards will be the quality standards referred to in Table 2.3.2 in Annex V to Directive 2000/60/EC and established in accordance with Article 17 of that Directive.

Pollutant	Quality standards
Nitrates	50 mg/l
Active substances in pesticides, including their relevant metabolites, degradation and reaction products (1)	0,1 μg/l 0,5 μg/l (total) (2)

2. The results of the application of the quality standards for pesticides in the manner specified for the purposes of this Directive will be without prejudice to the results of the risk assessment procedures required by Directive 91/414/EEC or Directive 98/8/EC.

3. Where, for a given body of groundwater, it is considered that the groundwater quality standards could result in failure to achieve the environmental objectives specified in Article 4 of Directive 2000/60/EC for associated bodies of surface water, or in any significant diminution of the ecological or chemical quality of such bodies, or in any significant damage to terrestrial ecosystems which depend directly on the body of groundwater, more stringent threshold values will be established in accordance with Article 3 and Annex II to this Directive. Programmes and measures required in relation to such a threshold value will also apply to activities falling within the scope of Directive 91/676/EEC.

Figure 6: Groundwater quality standards as formulated in Annex I of the GWD.

Table 1. Groundwater intervention values as defined in the Flanders region of Belgium.

Compound	Intervention values (µg/L)	Compound	Intervention values (µg/L)
HEAVY METALS & METALLOIDS		**POLYCYCLIC AROMATIC HYDROCARBONS**	
Arsenic	20	Naftalene	60
Cadmium	5	Benzo(a)pyrene	0,7
Chromium (III) (2)	50	Fenantrene	120
Copper	100	Fluorantene	4
Kwik	1	Benzo(a)antracene	7
Lead	20	Chrysene	1,5
Nickle	40	Benzo(b)fluorantene	1,2
Zinc	500	Benzo(k)fluorantene	0,76
MONOCYCLIC AROMATIC HYDROCARBONS		Benzo(ghi)perylene	0,26
Benzene	10	Indeno(1,2,3-cd)pyrene	0,1
Toluene	700	Antracene	75
Ethylbenzene	300	Fluorene	120
Xylene	500	Dibenz(a,h)antracene	0,5
Styrene	20	Acenaftene	180
CHLORINATED HYDROCARBONS		Acenaftylene	70
Dichloromethane	20	Pyrene	90
Tetrachloromethane	2	**CYANIDES**	
Tetrachloroethene	40	Cyanides (8)	70
Trichloroethene	70	**PESTICIDES**	
Monochlorobenzene	300	Aldrin + dieldrin	0,03
1,2-dichlorobenzene (4)	1000	Chlorodane (cis + trans)	0,2
1,3-dichlorobenzene (4)	1000	DDT + DDE + DDD	2
1,4-dichlorobenzene (4)	300	Hexachlorocyclohexane (g-isomer)	2
Trichlorobenzene (5)	20	Hexachlorocyclohexane (α -isomer	0,06
Tetrachlorobenzene (5)	9	Hexachlorocyclohexane(β-isomer)	0,2
Pentachlorobenzene	2,4	Endosulfan (α, β en sulfaat)	1,8
1,1,1-trichlotoethane	500	**CHLOROFENOLS**	
1,1,2-trichloroethane	12	2,4,6-trichlorofenol	200
1,1-dichloroethane	330	Pentachlorofenol	9
Cis+trans-1,2-dichloroethene	50	2-chlorofenol	15
CARCINOGENIC CHLORINATED HYDROCARBONS		2,4-dichlorofenol	9
1,2-dichloroethane	30	2,4,5-trichlorofenol	300
Vinylchloride	5	2,3,4,6-tetrachlorofenol	90
Trichloromethane	200	**OTHER ORGANIC COMPOUNDS**	
Hexachlorobenzene	1	Hexane (3)	180
TRIMETHYLBENZENE		Heptane (3)	3000
1,2,3-TMB	150	Octane (3)	600
1,2,4-TMB	150	Mineral oil (3)	500
1,3,5-TMB	150	Methyltertiairbutylether (10)	300

Due to the low mobility of the pollutants and the local scale, the presence of groundwater pollutants is mostly not on the radar of the large grid monitoring approach used at river basins and groundwater body scale. A single groundwater pollution spot may not affect the global groundwater quality much, but this does not justify concluding that 'local' pollutions are not to be considered when evaluating the groundwater quality. Much depends on the number of local pollution spots. Currently, inventories of 'local' pollutions for larger regions are mostly not available. Within AQUAREHAB, an exercise was made for the Flanders region where high amounts of data from contaminated site management are available. As an example, Figure 7 visualises spots where TCE-concentrations above the regulatory limit were measured. Overlays of maps for all listed compounds would be interesting to evaluate the extent of polluted groundwater.

Table 2 Comparison of critical levels for further investigation and/or risk assessment in Flanders region of Belgium, Spain and Italy for a number of pollutants classes.

PARAMETER:		Italia: CSC D.lgs 152/2006	Flanders (Be) Vlarebo, 2008 (80% intervention value)	Catalunya (Sp) VGI, 2010 (= intervention values)
BTEX				
Benzene	µg/L	1	8	90
Toluene	µg/L	15	560	
Ethylbenzene	µg/L	50	240	300
Xylenes (sum)	µg/L	10 (pX)	400	600
TPH (petroleum hydrocarbons)				
Mineral oil GC (C10-C40)	µg/L	350	400	
Metals				
As	µg/L	10	16	40
Cd	µg/L	5	4	70
Cr	µg/L	50	40	450 (CrVI)
Cu	µg/L	1000	80	
Hg	µg/L	1	0,8	1,5
Ni	µg/L	20	32	
Pb	µg/L	10	16	
Zn	µg/L	3000	400	
B	µg/l	1000		
CAH				
Dichloromethane	µg/L		16	750
Trichloromethane	µg/L	0,15	160	210
Tetrachloromethane	µg/L		1,6	30
Trichloroethene (TCE)	µg/L	1,5	56	50
tetrachloroethene (PCE)	µg/L	1,1	32	75
11-Dichloroethane (DCA)	µg/L	810	264	
12-Dichloroethane	µg/L	3	24	50
111-Trichloroethane (TCA)	µg/L		400	
112-Trichloroethane	µg/L		9,6	90
tDichloroethene	µg/L			240
Dichloroethene (sum)	µg/L	60	40	
11-Dichloroethene (CDE)	µg/L	0,05		60
Vinylchloride	µg/L	0,5	4	
CAH (sum)	µg/l	10		

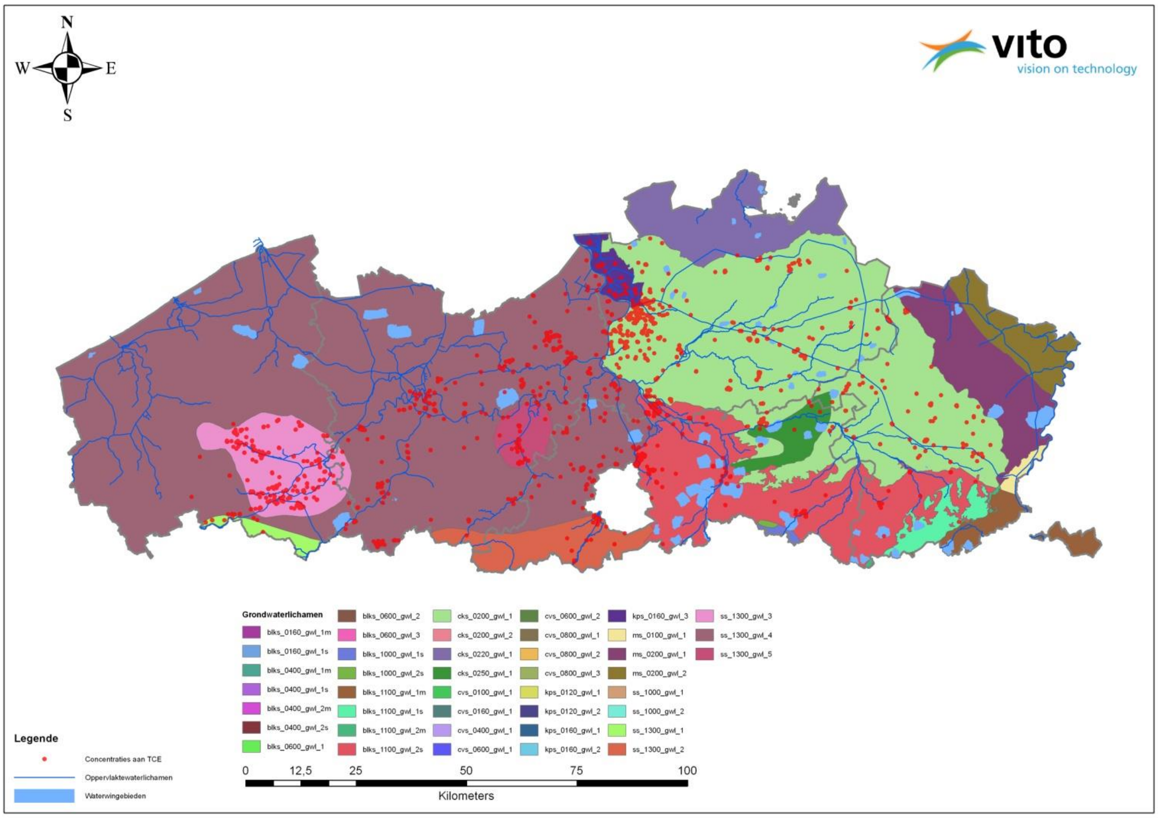

Figure 7 Map of Flanders with indication of groundwater bodies (coloured areas) and the monitoring wells where during 'local' groundwater management TCE-concentrations above the water quality limits were found.

<u>Differences between surface water & groundwater</u>

Groundwater and surface water do interact, but were found to be very different during the elaboration of the AQUAREHAB water management tool (Table 3).

(1) river water is much more dynamic than groundwater, where flow velocities can be as low as some meters per year. Once in the subsurface, pollutants can remain present for years even decades.

(2) the type of pollutants that are of concern in surface water and groundwater are different. The WFD lists mainly pollutants relevant for surface water;

(3) The procedures elaborated to evaluate good quality of surface water are only partially applicable for groundwater. For groundwater, the ecological aspect is considered not relevant, and hydromorphology has no meaning.

River basin management:

- focus on nitrates, pesticides = diffuse pollution linked to agricultural activities
- Shallow & also deeper wells > 200 m included
- Status of a whole groundwater body is based on results of different monitoring wells (may be limited to a few)

Groundwater management (at local scale):

- Pollutants originating from spills, accidents → CAHs (PCE, TCE, .. VC), BTEX, … MTBE,
- Data bases exist
- More shallow wells (many – per case)

Table 3 Comparison of groundwater and surface water.

	Surface water	Groundwater
Evaluating chemical quality	Tools available	Tools available
Ecological assessment tools	Available (each member state developed this for its own assessment)	Not existing
Economic analyses	Available	• Not elaborated • Considered a sensitive issue
Available data	Reporting requested by WFD Public domain	• Reporting requested by WFD/GD for 'listed' pollutants on groundwater body level • Many data on contaminated sites available with local authorities or soil remediation and public waste agencies. • Not structured for regional assessments • Not considered public domain – sensitive data
Ease to set-up monitoring netwerk	Surface water is relatively well accessible for sampling	• Limited accessible - Only via wells/drillings groundwater can be sampled. • The subsurface is a heterogeneous "dark grey"-box
Dynamics	Highly dynamic	• Less dynamic • Storage of pollutants • Impact for decades
Hetero-geneity	Relatively low	Very high

5 Ongoing actions by Europe

During the development of the GWD, it was not considered appropriate to list new quality standards that would be applied uniformly to all groundwater bodies throughout Europe, because of the natural variability of groundwater chemical composition and the lack of monitoring data and knowledge at the time. Article 10 of the GWD does foresee reviews of Annexes I and II every six years, of which the first was initiated in 2013.

6 Conclusions

Within the AQUAREHAB project, different innovative rehabilitation technologies for soil, groundwater and surface water were developed to cope with a number of priority contaminants (nitrates, pesticides, chlorinated compounds, aromatic compounds, mixed pollutions…) within heavily degraded water systems. Methods were developed to determine the (long-term) impact of the innovative rehabilitation technologies on the reduction of the influx of these pollutants, of which some are on the list of priority substances, towards the receptor. Possible connections and barriers between the innovative technologies and river basin management were evaluated. Some target outcomes of the project were (1) generic guidelines for the use & design of the technologies and (2) a generic river basin management tool that integrates multiple measures with ecological and economic impact assessments of the whole water system.

It was observed that Water Framework Directive (WFD) is mainly focussed on the long term and large scale management of surface water within water bodies – so that activities related to groundwater as part of remediation of contaminated sites are probably at a too local scale for the WFD and are mainly addressed by regional environmental authorities. This might be so but there could be more effort to harmonise standards and legislation concerning risk assessment and management of contaminated sites and pollution incidents. Since local groundwater contamination can often affect large groundwater bodies, it is still important to consider the effects of the parcel scale on the larger scale. Furthermore, groundwater is an important reserve for clean water in the future, and should be considered as a receptor and not just a path of pollutants to reach surface waters. Besides scale, the pollutant types listed in the WFD are mainly based on the needs of maintaining good surface water status, while other compounds are of more concern to groundwater quality status. In addition, the limited dynamics of groundwater complicates the use of tools & legislation developed for highly dynamic surface waters. At the moment it seems that more public information is needed concerning the status of the groundwater to increase the awareness and understanding of its impacts and the best remediation approach. In addition, it is important to establish relations between the use of the groundwater and the quality in order to assess whether all groundwater reserves are adequate for all uses or whether there should be restrictions on use depending on the quality.

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