Guidelines for aquifer monitoring programs within the frame of CO_2 geological storage

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While European countries are committed to reduce greenhouse gas emissions, the regulatory environment requires that future geological storage sites are chosen so as to ensure environmental protection. The state of the art showed the diversity of changes that may occur in subsurface aquifers impacted by a CO_2 leak (modification of the physicochemical properties of fresh water or in biological processes controlling the mobility of trace elements).
This poster presents monitoring guidelines for aquifers that could be impacted by CO_2 geological storage.

2 STAKES

In this context, the CIPRES project aimed at validating an aquifer monitoring methodology:

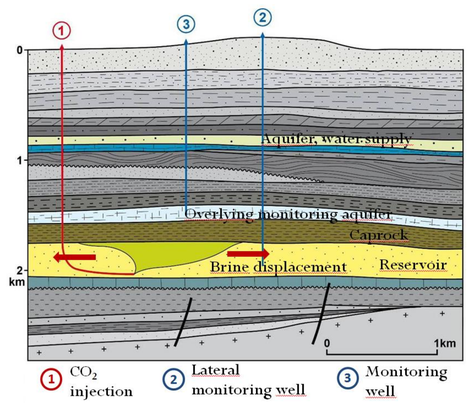
(i) analysis methods and parameter thresholds (useful to monitor and detect any anomaly related to a storage failure) and

(ii) water monitoring methods (including the ones for deep aquifers).

In near surface conditions, over short periods, these monitoring are easily managed, but it is usually more difficult when they have to be deployed over long periods or in deep conditions because of technological obstacles.

The CIPRES project:

- a R&D project, coordinated by BRGM
- associated partners: INERIS, laboratories from ISTO and IPGP, VERI and HYDRO INVEST
- started in January 2012 and lasted 42 months
- funded by ANR (799k€ for a total cost of 1800k€)



Adapted from BRGM and IFP

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3 REGULATION

Several regulations and guidelines are available for geological storage of CO_2 in order to secure the supply chain. However, guidelines towards groundwater resources are limited to brief and general recommendations. The ANR CIPRES project allowed improving the existing guidelines in terms of aquifers monitoring methodology.

4 DESCRIPTION OF THE PROPOSED AQUIFER MONITORING METHODOLOGY

The **produced guidelines** summarize the existing regulations and guidelines towards aquifers and geological storage of CO_2 in order to provide a **focused monitoring methodology on groundwater resources**.

The methodology proposes global aquifer monitoring practices for each CO_2 geological storage steps:

· **basic parameters** to be monitored, recommended for all aquifers in the area of review of the CO_2 storage complex;

· **specific parameters**, which will have to be customized according to the specific context of the studied case;

· **minimum recommendations** in terms of:

- **duration**: at least two years to acquire the baseline as a reference for monitoring;
- **monitoring frequency**: at least 2-4 times per year for the baseline acquisition, and 1-2 times per year for the operational monitoring; and
- **location**: in the monitoring aquifer and in vulnerable aquifers (aquifers that may be damaged under special circumstances).

5 PARAMETERS RECOMMENDATION FOR AQUIFERS MONITORING

	Storage steps	Regional study	Exploration	Construction	Exploitation		Monitoring period	Post responsability transfer period
	Monitoring	Environmental baseline	Monitoring plan development	Operationnal monitoring baseline	Operationnal monitoring	Reinforced monitoring	Post-closure monitoring	Long term monitoring
Basic parameters	groundwater level	x	x	x	x	x	x	x
	pH, ORP, T, electrical cond.							site specific
	alkalinity, major anions and cations, DOC							site specific
	dissolved CO_2, dissolved O_2							site specific
Specific parameters	metallic trace elements	x	x	x	x	x	site specific	
	hydrocarbures and co-injected substances	x		x		x	site specific	
	isotopic composition ($^{12}C/^{13}C$, ^{3}H, ^{18}O)	x	x	x		x		
	N_2, Ar, H_2S, CH_4 and other alcanes, He, co-injected gas...	x	x	x		x	site specific	
	microbiologic parameters	x		x		x		

6 FREQUENCY & LOCATION RECOMMENDATION FOR AQUIFERS MONITORING

Storage steps	Regional study	Exploration	Construction	Exploitation		Monitoring period	Post responsability transfer period
Monitoring	Environmental baseline	Monitoring plan development	Operationnal monitoring baseline	Operationnal monitoring	Reinforced monitoring	Post-closure monitoring	Long term monitoring
Monitoring objectives	Setting of the full initial state of aquifers (before any anthropogenic interference) then compare any potential changes due to storage	Definition of storage risks and monitoring to be deployed to manage them	Setting of the initial status once operating and monitoring wells are completed	Establishment of groundwater chemical status to detect any anthropogenic trend	Assessment of potential impacts of detected CO_2 leakage (and/or remedial actions) on aquifers	Monitoring of post-operational risks trend (and / or remedial actions) on aquifers	Monitoring of long term risks trend (and / or remedial actions) on aquifers
Data sources	Sampling and measurements from PZ and existing wells, and collection of existing data	Existing data and env. baseline results, data acquisition on new wells/PZ	Sampling and measurements from piezometers (PZ) and wells used for the operational monitoring				Sampling and measurements from PZ and existing wells
Monitoring duration	Site specific (hydrogeology, geology)						
	During at least two years. To start ASAP and up to the exploration beginning		During at least two years		> than the period with detected anomaly	> 20-30 years	
Monitoring frequence	High enough to be representative of analyzed parameters (at least 2 to 4 times/year)		High enough to be representative of analyzed parameters (at least 2 to 4 times/year). ≥ than op. monitoring	To be defined according dispersion/variability and geological background (at least 1 to 2 times/year). Op. monitoring baseline to conduct every 5 years min	> than op. monitoring	Similar to the one of the op. monitoring at the beginning, then lighter	From every 5 years to 4 times/year
Monitoring density and location	Site specific (hydrogeology, geology) and according available wells/PZ						
	Overlying monitoring and vulnerable aquifers (including drinking water aquifers (DW)). At least for one sampling point upstream and two downstream of the injection well, and at least one in each vulnerable area						DW aquifers; overlying monitoring aquifers if needed
				More monitoring points than the baseline, but less monitored parameters	> than op. monitoring		

7 CONCLUSIONS

First guidelines towards aquifers and geological storage of CO_2 that focuses on monitoring methodology for groundwater resources.

Moreover these guidelines propose a necessary and sufficient monitoring regarding parameters, frequencies and location of measurements.

8 REFERENCES

· European Union, DIRECTIVE 2009/31/EC on the geological storage of carbon dioxide, 2009.

· European Union, Groundwater Directive 2006/118/EC on the protection of groundwater against pollution and deterioration, 2006.

· Lions, J., L. De Lary De Latour, N. Devau, M. C. Dictor, S. Dupraz, M. Parmentier and P. Gombert. État de l'art sur les impacts potentiels du stockage géologique du CO2 sur la qualité des eaux souterraines. Rapport final. BRGM/RP-64883-FR, INERIS DRS-12-127377-09813. 136 p. 2015.

· Grellier, S., J. Lions, P. Gombert. Guide méthodologique pour la mise en œuvre des programmes de surveillance des aquifères à proximité des sites de stockage géologique de CO2. 99 p. 2015.

· US EPA. Geologic Sequestration of Carbon Dioxide - Underground Injection Control (UIC) Program Class VI Well Office of Water. 2012-2013.

· World Resources Institute (WRI). CCS Guidelines: Guidelines for Carbon Dioxide Capture, Transport, and Storage. Washington, DC: WRI. 2008. 10 G Street, NE. Suite 800. Washington, DC 20002.