Water quality and geothermal projects

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Authors: A. Manzella[1], S. Giamberini[1], G. Montegrossi[1], D. Scrocca[1], C. Chiarabba[1], P. Valkering[2], S. Delvaux[2], V. Harcouët-Menou[2], F. Branchu[3], J. Maury[3], C. Maurel[3], C. Bozkurt[4], A. Nádor[5], S.R. Guðjónsdóttir[6], M. Guðmundsdóttir[6], G. Ravier[7], N. Cuenot[7], D. Bonciani[8], L. Torsello[8], M. Luchini[9], F. Batini[10], P. Dumas[11]

Author'(s') affiliation: [1]CNR, [2]VITO, [3]BRGM, [4]JESDER, [5]MBFSZ, [6]Orkustofnun, [7]ES-Géothermie, [8]COSVIG, [9]Enel Green Power, [10]Rete Geotermica, [11]EGEC

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Water quality and geothermal projects

There are different potential environmental effects on underground and surface water resources from deep geothermal projects that require a legal framework for prevention and mitigation. They include potential connection of non-targeted aquifers *via* the wellbore, modifications of reservoirs' physical and chemical status due to extraction of geothermal fluids, chemical and temperature effects due to both the discharge of geothermal water and drilling fluids onto and into surface/underground water bodies and the reinjection of geothermal fluids after production.

The European regulation for water-ecosystem protection (Water Act[1]) and its national implementations cover almost all issues related to this topic, including minimization of water amount.

However, water management practises may differ in the Member States.

The following analysis distinguishes the practises used to avoid aquifers' interferences due to inexpert drilling from those regarding the discharge of geothermal water into the ecosystem and water reservoir after production.

Regarding the **potential aquifers' interferences**, the situation among the countries mapped in GEOENVI and the analysis of the collected data are synthetised in Fig. 1 and Table 1. On the other hand, Fig. 2 and Table 2 synthetise the situation regarding the **potential chemical and temperature effects due to water discharge**.

[1] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

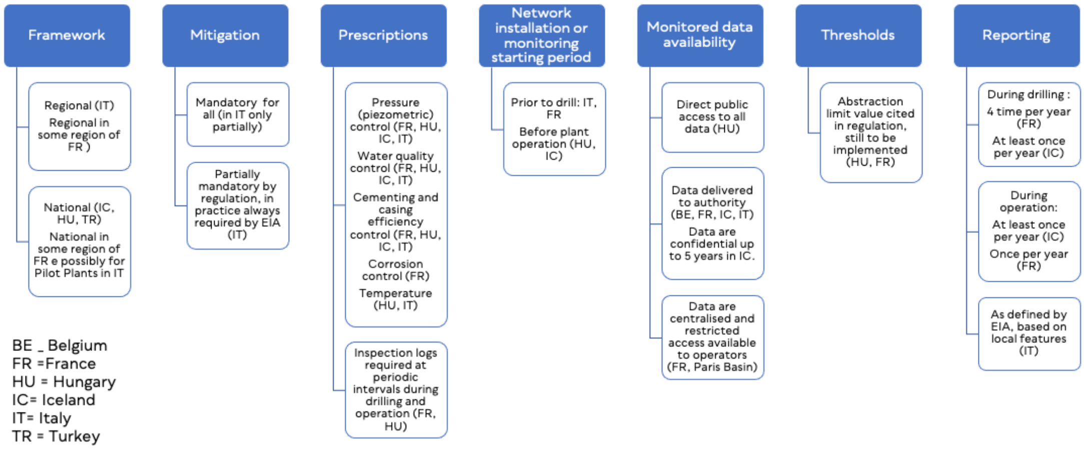

Figure 1 Diagram showing in synthesis how regulations and solutions for safety issues are established at the national level in the GEOENVI participating countries to mitigate the potential impacts of aquifers' interferences.

Table 1

Similarities	Differences
○ All countries, except Turkey where aquifers are only mapped, require a plan for excluding interference with non-targeted aquifers during drilling; ○ Pressure and groundwater quality control and cementation inspection are explicitly required in France, Hungary, Iceland, and Italy; ○ Very detailed prescriptions are required in France, Hungary, and Iceland; ○ A code of good practices for drilling is available in Flanders in Belgium, France, Italy. In most cases, the good practice codes are suited for shallow groundwater wells but are not well adapted for deep geothermal wells.	○ Flanders (Belgium) adopts prescriptions only for the drilling phase; ○ Corrosion control is required only in France and partly in Italy; temperature control is required only in Hungary and partly in Italy; ○ The concept of "abstraction limit value" is present in Hungary and France (as the maximum volume of fluid to be extracted by a given operation, an indicator to avoid overexploitation); ○ Data are public in Hungary (well-log books), and are mostly confidential in Belgium, France, Iceland, and Italy; data are centralised and restricted access is available to operators in Paris Basin, France; ○ Reporting frequency is very variable.

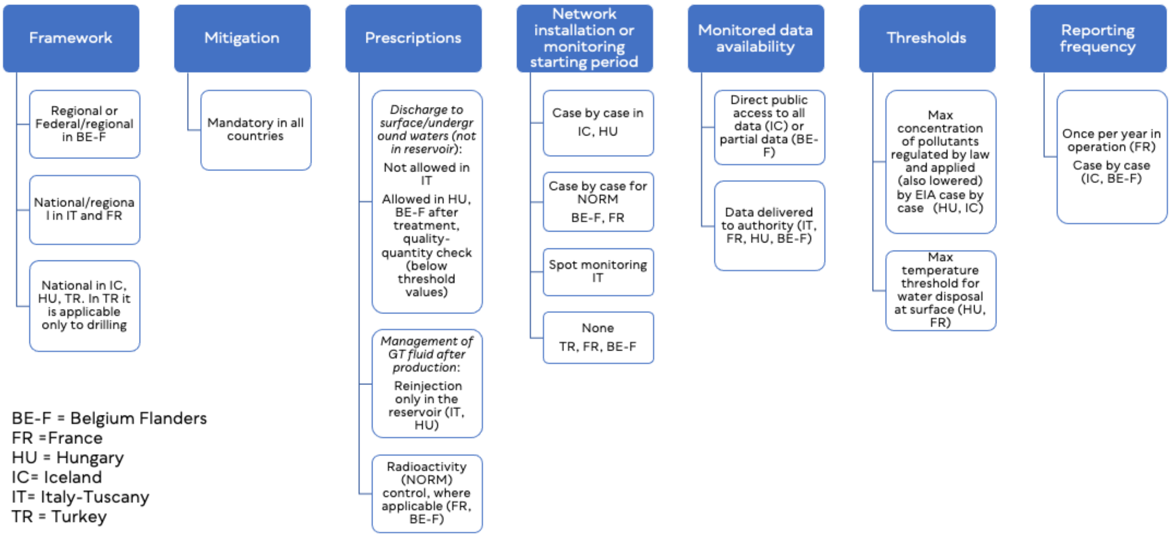

Figure 2 Diagram resuming how regulations and solutions for safety issues are established at the national level in the GEOENVI participating countries to mitigate the potential impacts of the discharge of geothermal fluids.

Table 2

Similarities	Differences
○ Controlled water management, both as management of waste and water and ecosystem protection, is required in all countries; ○ Where applied, reinjection is allowed only in the same reservoir; ○ Only geothermal fluids are used for the injection in the reservoir.	○ Discharge of water in surface water bodies, after quality-quantity check, is allowed in some countries and forbidden in others; ○ Only Hungary establishes differential thresholds for pollutants depending on the application (e.g., balneology, district heating, etc.); ○ Monitoring data are public only in Iceland. Partial release of data is mentioned in Italy and Belgium-Flanders.

The Guidelines for the different phases of geothermal drilling operations in France (Paris Basin)

The document, edited by BRGM in association with ADEME and in consultation with professionals from the geothermal industry, presents technical aspects associated with well drilling (e.g., well completion, inspection) and provides recommendations for each of them. Several relevant information extracted from the document is listed below:

Well completion *(data sheet 21)*

- Overview of main parameters used for the well completion design and recommendations to ensure the well integrity.
- A technical protective casing is installed in the first hundreds of meters (300-400 m).
- Deeper protected aquifers are secured by means of double casing.

Cement logging *(data sheet 72)*

- *Overview* of available tools for cement logging, their limits, and conditions for a proper cement logging interpretation.

Casing logging *(data sheet 73)*

- Information about available logging tools for steel and composite casing control.
- A method is proposed to quantify the damage from casing logging measurements.
- Regular casing inspection due to mechanical damage, corrosion, or bacteria is recommended.
- Recommended frequency of inspection:
  - every 3 years for injection wells;
  - every 5 to 6 years for production wells.

The document is available on-line in its original, French, version and English version[2].

[1] http://infoterre.brgm.fr/rapports/RP-65443-FR.pdf
[2] https://www.geothermies.fr/outils/guides/good-practice-guide-lessons-learned-deep-geothermal-drilling

Two examples of regulation and practices for the abstraction limit

In **France**, the limitation of geothermal power extracted inside a defined perimeter is specified within the exploitation license issued for each operator. The regional deconcentrated authority collects notably production history to control the volumes of fluid and thus the geothermal power extracted each year.

In **Hungary**, where the definition of abstraction limit value ("Mi") is enforced by regulation to prevent the aquifers' depletion (especially when fluids are not reinjected, see also "Discharge of geothermal fluids"), a good practice for its determination exists for Lake Héviz, Europe's largest thermal karstwater lake in the western part of Hungary. There is extensive use of thermal water around the lake (different hospitals, hotels, balneological centres), which required a science-based recommendation for issuing new licenses (i.e., new water abstraction volumes) that do not threaten the yield and temperature of the lake itself and the existing uses.

The developed hydrogeological model made it possible to quantify the available amount of groundwater (water budget) and heat, outlining 3 different protection zones with different Mi values.

A Case study: Hungary

A good example of safety practice is available in **Hungary**, where the thermal groundwater abstracted for energetic purposes may be reinjected to the same aquifer after utilization. Still, surface disposal/discharge is also allowed. The input of used water into water bodies can happen only in a way that does not threaten the natural processes and the quality and quantity renewal of the water reserves.

The national regulation contains provisions on the threshold values of various contaminating materials. It specifies threshold values for thermal water discharge into surface recipients (e.g., rivers, streams) ranked in 3 categories: therapeutic, balneological, and energetic. The highest allowable threshold values are provided for the therapeutic utilization (5000 mg/l of total dissolved solids), thus appreciating its economic and public health value. In contrast, lower values are allowed for balneological (2000 mg/l) and energetic (3000 mg/l) utilization. The allowed heat load is 30 °C in all 3 categories (i.e., this is the maximum allowed temperature at which thermal water can be released at the surface).

If any of the used thermal water components are above the threshold values, then the thermal water has to be discharged into an artificial lake. In case the used thermal water and the cleaned water of the settlement have no harmful interactions, they may be drained together.

Recommendations

1. Sharing and adopting best practice regarding well design, monitoring, and abstraction limit

Guidelines to evaluate and control wells would be an improvement to the current practices that rely on the operators' expertise. For example, the mentioned guidelines used in France (based on the experience acquired in the Paris Basin) can be taken into consideration as a basis for the harmonized best practices, notably protection of shallow aquifers. It would also be important to establish guidelines to handle the most difficult cases, such as if corrosive fluids or gas co-production are present.

2. Making evidence of water monitoring and control available to the public

Data from groundwater monitoring, to follow potential impacts on other aquifers above the target formation, should be available to experts, e.g., national observatories, geological surveys (raw data), and the general public (in aggregated form, presenting the main conclusions regarding the control and monitoring carried out to avoid incorrect use). This recommendation implies adopting an Open Data Policy; it links to the topic "Data sharing".

3. Enforcing control of aquifers

The current legislation (Water Act1[1]) regulates the control of the quality and quantity of aquifers. Regulations are applied in most cases, but if this control is not carried out or information is scarce, the changes in aquifers' status may be perceived as linked to geothermal operations. In such cases, information on geothermal well integrity solves the issue; however, the monitoring of aquifers' quality (e.g., chemical and temperature control) and quantity (e.g., groundwater levels) and data sharing should be an established good practice to be organised at the local level. See "Creation of local benefit" for a reference to this recommendation.

4. Evaluating the medium and long-term behaviour of the geothermal reservoir status

First, the medium and long-term behaviour of the geothermal reservoir should be assessed by numerical modelling based on existing data and on the foreseen production scenario. Then, the models must be calibrated and updated once historical data becomes available. This evaluation and the reservoir follow-up and control would testify to the sustainable use of geothermal reservoirs, i.e., that abstraction does not exceed the recharge rates (natural, or *via* reinjection of used geothermal fluids) or alter the chemical composition. Data should be periodically provided to the controlling authorities.

5. Where surface discharge is allowed, establishing frequent monitoring and harmonisation of temperature and chemical thresholds for geothermal water

As in Hungary, where surface discharge is allowed, a comprehensive monitoring system would allow an appropriate environmental assessment and control. Some environmental quality parameters may be controlled remotely.

6. Executing reinjection of fluids

This recommendation, aimed at minimising the reservoirs' depletion and avoiding chemical and thermal impacts on surface ecosystems, should be applied to direct use of geothermal fluids, or at least those involving flow rates higher than 10 litres/sec. In the case of bathing and swimming applications, where human contaminations are unavoidable, the thermal water not getting in direct contact with humans (e.g., used only for heating of the pools) should also be reinjected.

7. Harmonising the chemical classification for the toxicity of inhibitors in Europe and among sectors (e.g., oil and gas)

Contact: Annamária Nádor, Mining and Geological Survey of Hungary, nador.annamaria@mbfsz.gov.hu

Coordinated by: EGEC, com@egec.org

GEOENVI website: www.geoenvi.eu

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This document is part of a series conducted in the framework of the GEOENVI project. Its aim is to respond to the need for harmonization of environmental regulations and to address concerns about potential environmental effects of geothermal projects in Europe.

GEOENVI strives to facilitate the incorporation of geothermal energy in Europe's energy transition, while respecting sustainability and creating a robust strategy to answer environmental concerns. The project developed a unique Life Cycle Assessment methodology for evaluating geothermal projects.