Predicting microbial survival and activity in engineered barrier systems

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Understanding microbial survival and activity within the changing environment of the EBS

Microbial activity within the engineered barrier system (EBS) of a geological disposal facility (GDF) could affect many aspects of the safety functions of a GDF.

EBS environmental conditions (e.g. temperature, pH) vary over time and space and are influenced by geological setting, waste type and repository design (Figure 1).

Exposure to changes in temperature, pH, radiation, salinity, saturation, and availability of nutrient and energy sources can limit microbial survival and activity.

Literature data allows limits to life for environmental conditions to be established.

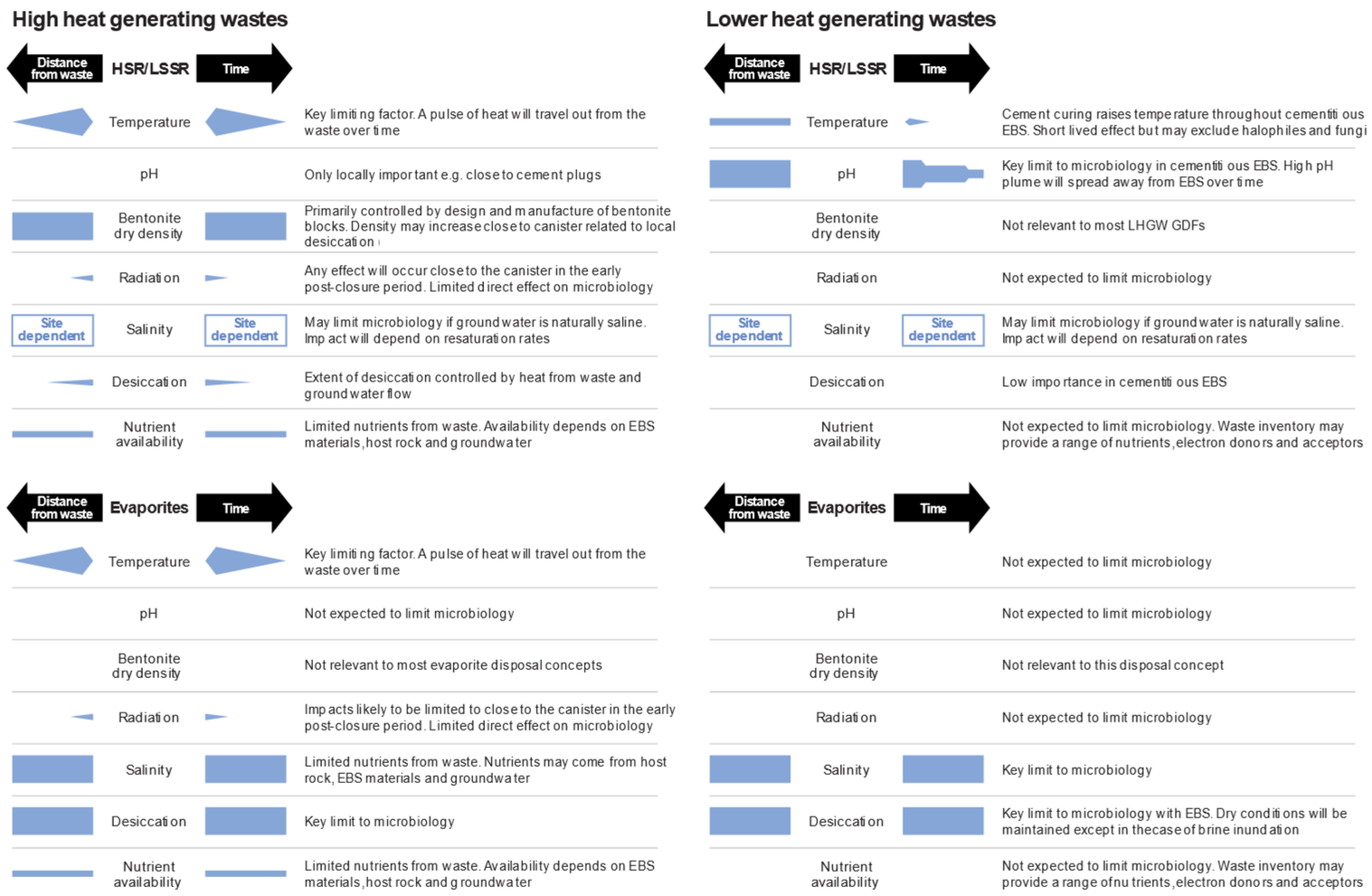

Figure 1 (right). Overview of environmental variable changes post-closure in the EBS, depending upon geological setting (HSR, LSSR, evaporite) and waste type (high heat or lower heat generating wastes).

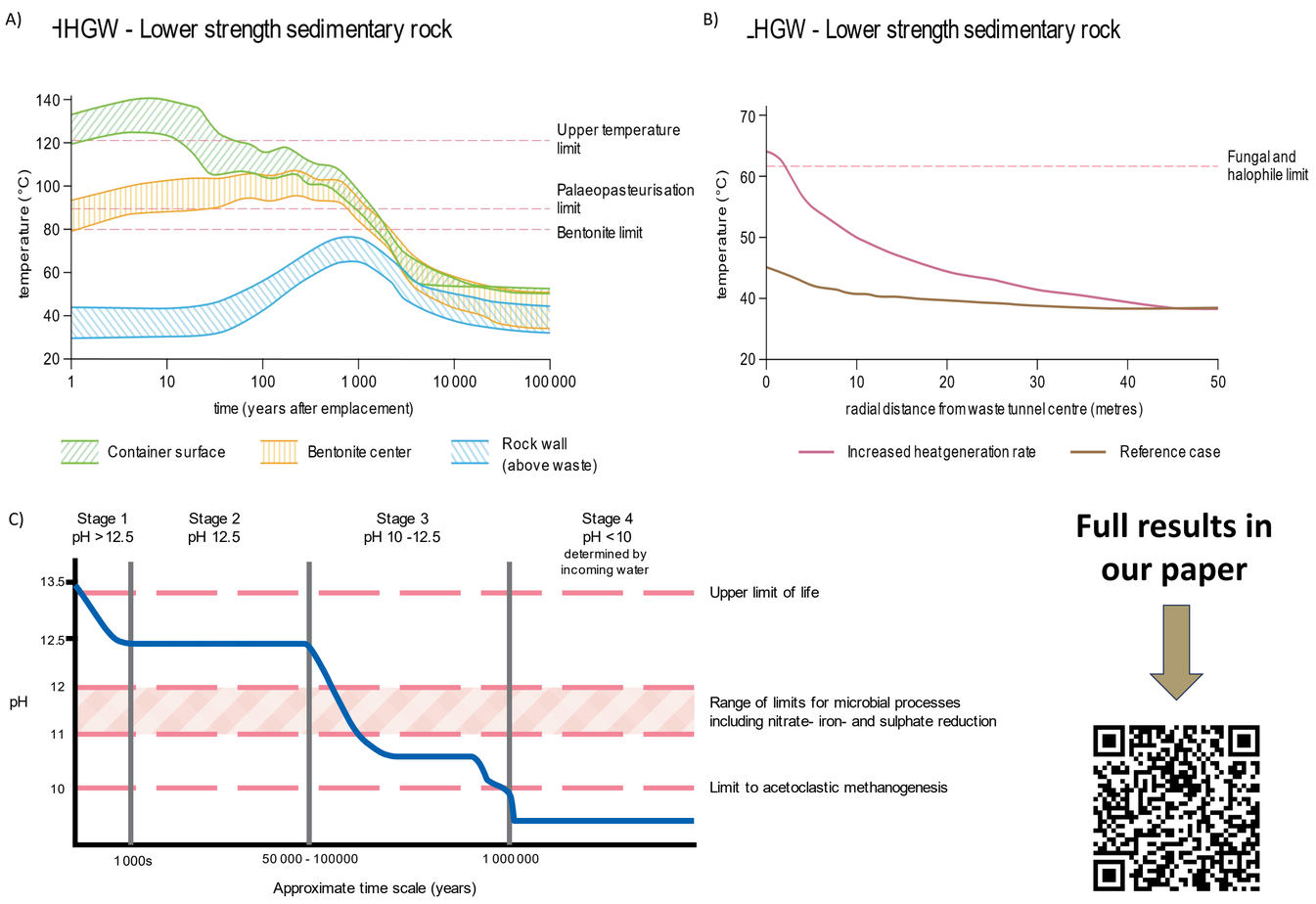

Figure 2 (above). Overlaying the defined microbial limits onto modelled post-closure data allows times or locations of possible microbial activity to be clearly identified.

Full results in our paper

Example results - Temperature

Applied temperature limits (Figure 2A, B).

- 122 ˚C: Upper limit to life. High confidence that microbial activity cannot occur under these conditions.
- 90 ˚C: Above this palaeopasteurisation limit, microbial activity is unlikely but cannot be ruled out.
- 80 ˚C: Limit in compacted bentonites (based on laboratory experiments).
- 61 ˚C: Limit for halophilic (salt-loving) microorganisms.

Example results - pH

Applied pH limits (Figure 2C).

- pH 13.2: Upper experimental limit. High confidence that microbial activity cannot occur in these conditions.
- pH ~11–12: Microbial activity above this limit is unlikely but cannot be ruled out.
- pH ~10 is the limit of acetoclastic methanogenesis.

Mapping microbial habitability in the EBS

If data for multiple environmental parameters are available, they could be combined to identify “habitability spaces” showing when and where microorganisms could survive in a post-closure environment.

In **Figure 3** microbial activity only needs to be considered in areas where the conditions for all considered environmental variables lie below the limit set (**grey areas**).

By applying this approach, priority areas for future microbiological research can be identified from modelling the physical or chemical characteristics of the a GDF.

This approach could be used to refine R&D strategies and define boundary conditions for experiments.

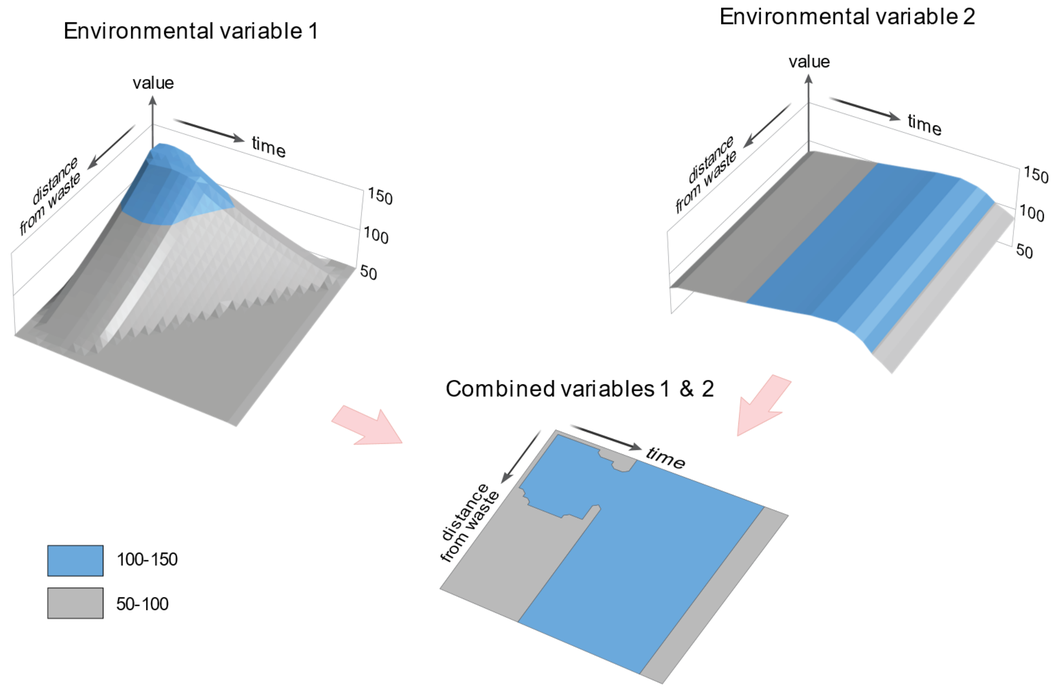

Figure 3 (above). Visualisation how limits for multiple environmental variables can be combined to map ”habitability spaces”.

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Figure 2A modified from Nagra Report NTB-21-02 . Figure 2B modified from Nagra Report NTB-01-04. Figure 2C modified from figure that appears in multiple sources.