Gas Generation Experiment with LLW – Corrosion of Metal Samples

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Introduction

In Finland low-level radioactive waste (LLW) produced by nuclear power plants includes scrap metals and considerable amounts of paper products, cardboard, cotton gloves and plastics. Compressible LLW is compacted in carbon steel drums and disposed in repositories situated inside the bedrock in the plant sites at a depth of 60–110 meters. The biodegradation of cellulose-based LLW in anoxic conditions can result in gas generation and accelerate corrosion, and enhance the mobility of radionuclides from the repository to the surrounding environment.

Gas Generation experiment (GGE)

In 1997 the GGE was constructed to simulate the amount of gases generated from LLW to estimate the risks for the final disposal (Fig. 1). In GGE carbon steel drums with the volume of 200 L were filled with LLW and the GGE was filled with river water. The GGE has been monitored for volume and composition of generated gas, water chemistry and microbiology (Small et al., 2017).

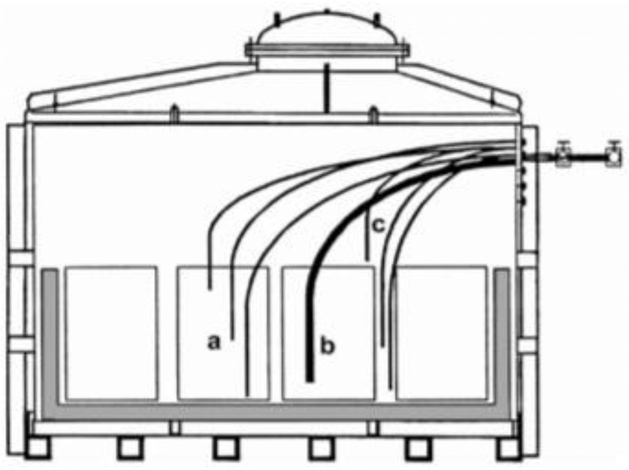

Figure 1. The GGE with waste drums containing LLW and sampling lines for water samples and capsules. The amount of cellulose-based materials inside the drums varied from 5 to 95 w-%. Before closing the GGE was filled with local river water and has been maintained at temperature of 8-11°C. (Small et al., 2017).

Capsules and steel samples

Capsules containing a piece of drum steel and LLW were loaded to the experiment (Figs. 2). They were located in within waste drums and in tank water. Capsules have been removed at certain intervals and used to study the corrosion rate of steel (ISO 8407) and corrosion products with an X-ray diffraction spectrometer (XRD). The amount of methanogens (*mrc*A gene copies) in water samples taken from the drums were measured by quantitative PCR.

Figure 2. Capsules containing maintenance waste LLW and a piece of drum steel have been loaded to the GGE tank in 2001 and removed at certain time points (2013, 2015 and 2017) to study the corrosion rate of steel. In addition, microbial biofilms formed on the surface of waste materials and the steel plates were studied.

Results and discussion

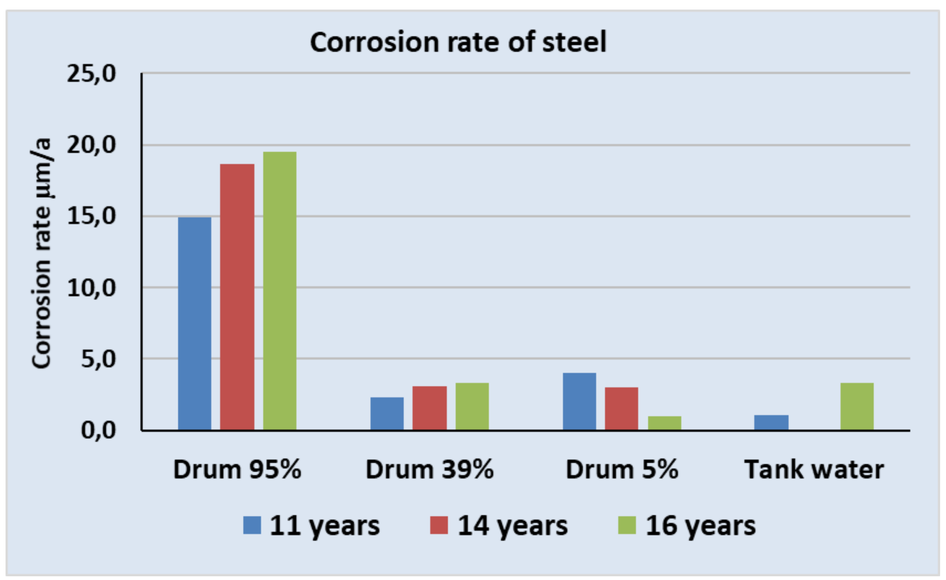

Figure 3. Corrosion rate of steel in different compartments of GGE (tank water and drums containing various amounts of cellulose) after 11, 14 and 16 years. The pH conditions inside the drums were close to neutral during the measuring period.

- **The corrosion rate of steel was highest inside the drum containing 95 w-% of cellulose-based LLW (Fig. 3).**
- **The concentration of soluble ferrous iron Fe^{2+} was also high in water sample taken from this drum indicating dissolution of the carbon steel.**
- **The amount of dissolved organic carbon was three times higher in the drum with 95 w-% of cellulose compared to the drum with 5% of cellulose.**
- **One possible reason for more rapid corrosion rate can be the increased microbial activity. The amount of methanogens was one logarithmic unit higher in the drum with 95% of LLW compared to the other drums.**
- **The main corrosion product in steel plates in all GGE compartments was siderite $FeCO_3$, which is generally formed under methanogenic and acetogenic conditions.**

References

Small, J., Nykyri, M., Vikman, M., Itävaara, M., Heikinheimo, L. 2017. The biogeochemistry of gas generation from low and intermediate level nuclear waste: modelling after 18 years study under in situ conditions. Appl. Geochem. 84, 360-372.

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