Motivation

- Characterisation and monitoring of in-situ remediation of chlorinated hydrocarbon contamination using an interdisciplinary approach (MIRACHL project)
- Geophysical induced polarisation (IP) measurements useful for knowledge about (e.g.) resistivity, hydrogeological parameter, inner structure of a material/sample

Can bacteria affect the geophysical induced polarisation (IP) signal?

How do bacteria affect the geophysical IP signal?

How much do the bacteria influence the IP signal?

Scientific question

- Idea/Experiment: Microbiological and geophysical laboratory investigation of bacteria in a sand environment
- Two experiments were conducted

Microbiology

Investigating the influence of Escherichia coli (E. coli) on sand:

**Experiment 1:**
- **step 1:** 9 individual samples filled with sand, media (nutrient food) and E. coli bacteria
- **step 2:** 8 individual samples filled only with sand and media
- **step 3:** 9 individual samples filled only with sand and water

**Experiment 2:**
- **step A:** 9 individual samples filled with sand, media and E. coli (just like step 1/Exp. 1)
- **step B:** 9 individual samples filled with sand, media and E. coli (double amount)

All material was sterilised before and the prepared samples were incubated in a temperature controlled shaker at 30°C with gentle mixing (fig. 1a–c).

To ensure E. coli was growing, parts of the fluid were put on agar plates, incubated at 37°C overnight and counted (fig. 1d).

**Experiment results**

- After two days the maximum number of living bacteria was reached. Thereafter the bacteria decreased/dead (fig. 4a).
- Fluid conductivity is higher when (E.coli) bacteria are present (13 - 16 mS/cm, fig. 3) due to the presence of bacterial cells and/or their degradation products
- In general, SIP resistivity values are smaller for the E.coli than for the media and water samples (fig. 5a, c, d). This is in accordance with the fluid conductivity (fig. 3)
- The SIP phase signals are higher for the E.coli samples than for the media and water samples. Although, the signals are very small and no tendency apparent
- Differences in bacteria concentration (step A and step B) affect fluid conductivity (fig. 4b)
- pH is similar for the first 5 days, afterwards divergent (fig. 4c)

**Conclusion & Outlook**

- Bacteria influence the IP signal
- Resistivity is decreasing with increasing bacteria density
- Even small amounts of bacteria (0.1%) inoculation decrease the resistivity significantly
- Also dead bacteria influences the resistivity
- Phase is increasing with bacteria but very slightly and without significant trends so far

Outlook: further IP experiments are necessary to:

- Improve the measurement technique and the experimental set up
- Investigate natural contaminated soil samples
- Measure in time domain IP

Geophysics

**Scientific question**

- To measure IP, the samples were taken out at different days to ensure different amounts of bacteria
- The sand was filtered to separate the fluid (fig. 2a) and carefully packed in the SIP sample holder (fig. 2b)
- Samples were measured immediately with SIP (fig. 2c) after packing and held in the sample holder for at least 24h, during which the samples were measured repeatedly (at least 3 times)
- Fluid conductivity, pH and temperature of the liquid removed by filtering were also measured

**SEM/qPCR**

DNA analysis was carried out and SEM (scanned electron microscopy) pictures were taken afterwards to confirm the bacteria in the sand.

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