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DYNAMICS OF GROUNDWATER QUALITY DURING FULL SCALE LANDFILL MINING

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The site

- Landfills and dumps

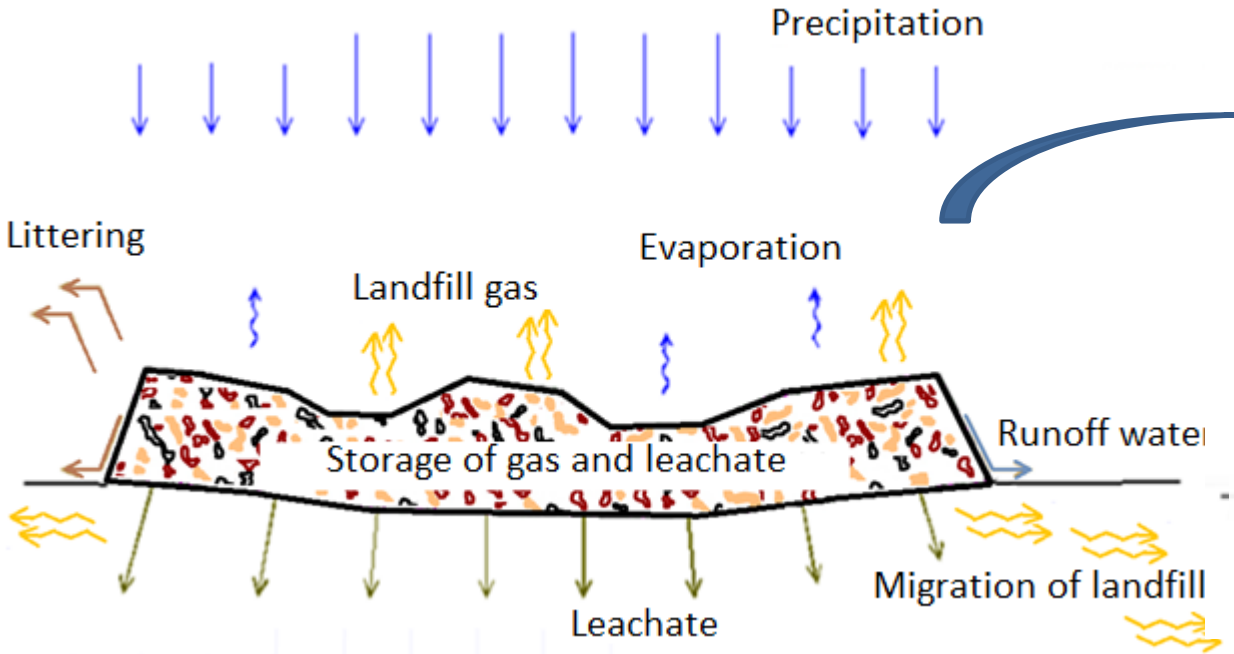
2020 = only 5 active LFs

Case study: Kudjape

Kudjape landfill/dump, Saaremaa Island, Estonia

- In operation 40 years, most active during last 20 years
- Estimated volume 200.000 m^3
- Municipal waste
- NO bottom liner
- By law had to be capped 2013
- Main issue: Landfill gas
  - Gas collection? Passive ventilation?

Typical cover design in small dumpsites

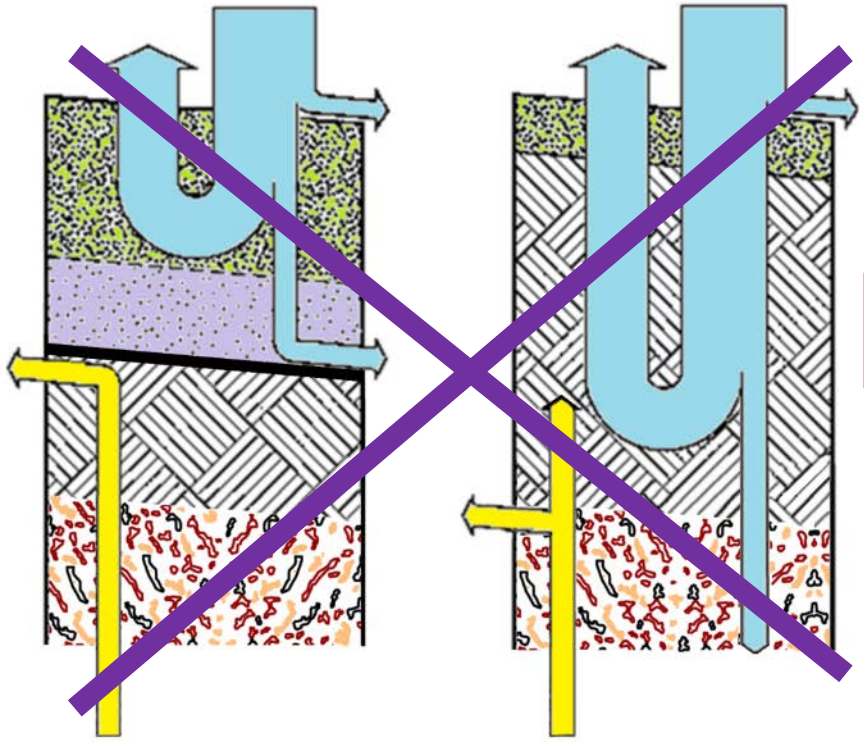


Kudjape case was different

- Simple closure design of a LF was **not agreed** by authority;
  - Fear of gas → 1,5 m cover layer was prescribed;
- Cover material was not available.
  - Cover material demand 60.000 t – locally not available
  - To transport it from distances/overseas?
  - Is it ethical to force LF using clean soil for covering waste?
- **What if** we take cover material from the same landfill?
  - This technology is called **Landfill Mining** (LFM)

Main objective: fine fraction for cover layer

Impermeable cover layer



Semi-permeable cover layer

Methane degradation layer (taken from LF)

Mineral gas distribution layer (taken from LF)

(Modified after Tchobanoglous et al., 1993)

Methane degrades: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

What about WATER?

- Water pollution is an environmental concern in every landfill-related project
- During Landfill Mining (LFM):
  - the surface of the excavated area expands
  - the area of the stored excavated waste expands
  - it rains and snows
- Information about water pollution during LFM – limited.
- Stormwater and leachate – risk?

Excavation in progress

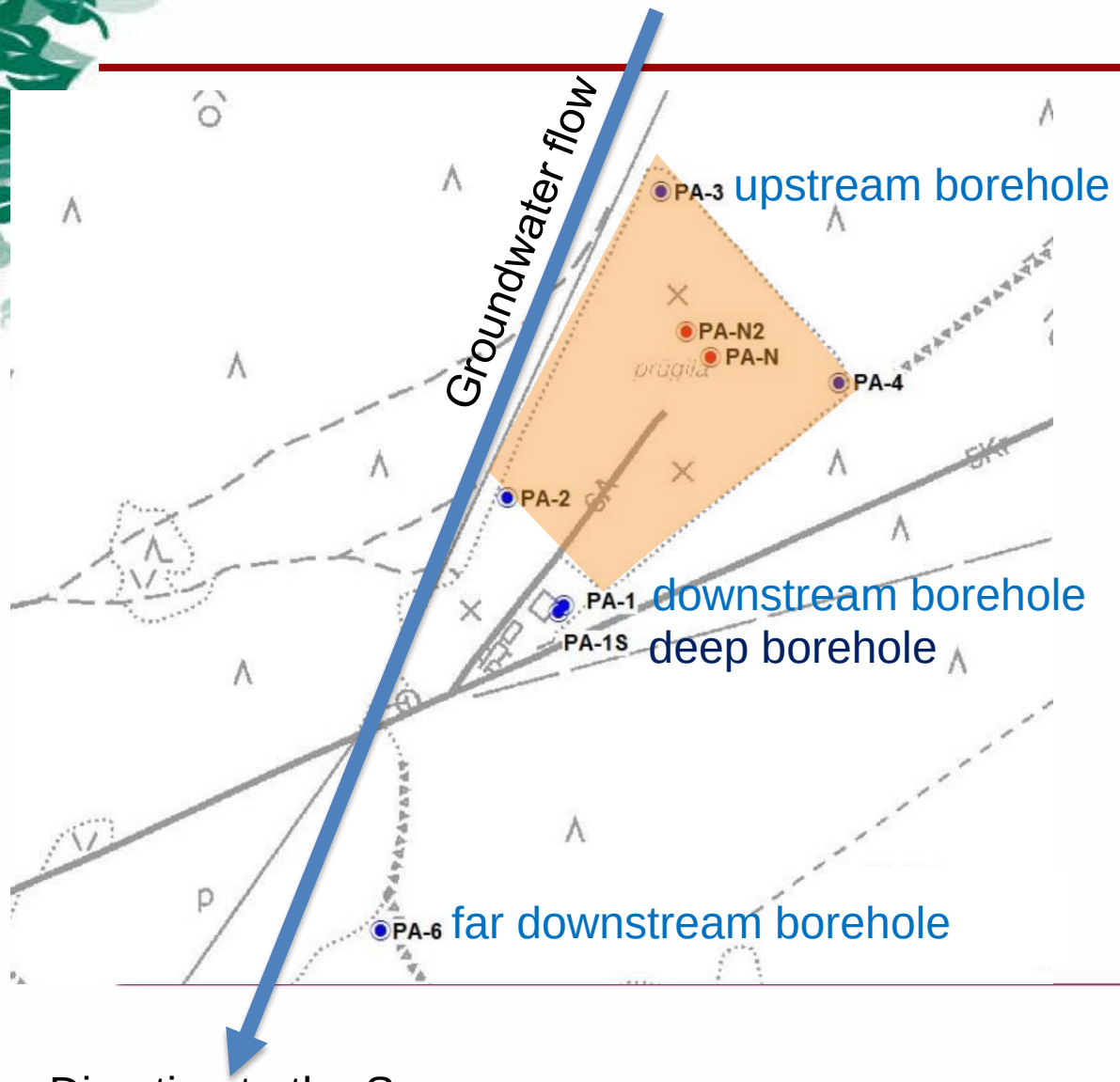
- About 55.000 tons were excavated during one year.

Water!

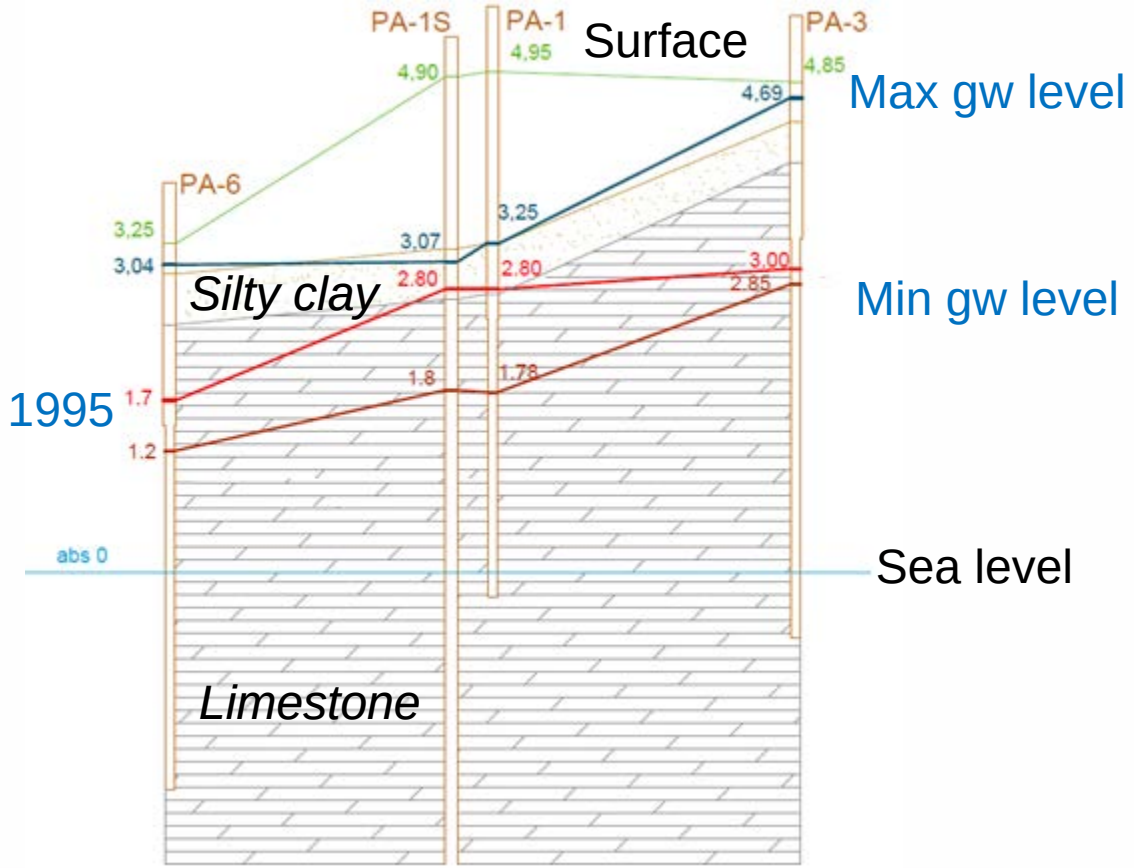
Monitoring & water quality

- Objective: to monitor the quality of groundwater
  - before the LFM, during the project and until 2020
- Sub-objective:
  - To establish groundwater monitoring network
  - To create sampling protocol
  - To monitor precipitation
  - To link the progress in excavations with groundwater quality
  - To assess the impact of LFM on the groundwater quality

Monitoring network



PA = boreholes









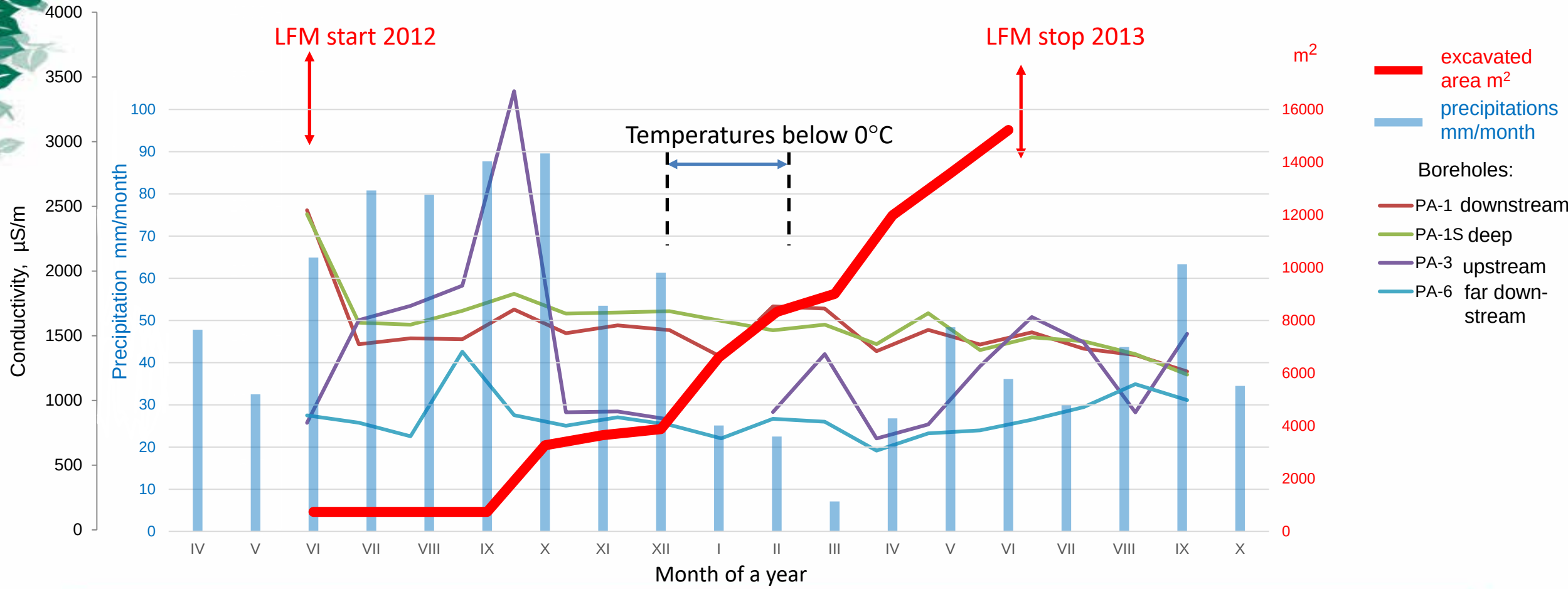

Parameters

- Monitoring of 4 groundwater wells + ditch
  - In-situ (pH, t, EC, O_2)
  - Ex-situ: (BOD, COD, F, NH_4, NO_3, NO_2, N_{tot}, Cl, Mn, Fe, P_{tot}, DS, Metals, PAH, BTEX, TPH_{10-40}, phenols)

- Fine fraction
  - Leaching & toxicity

Unpublished data

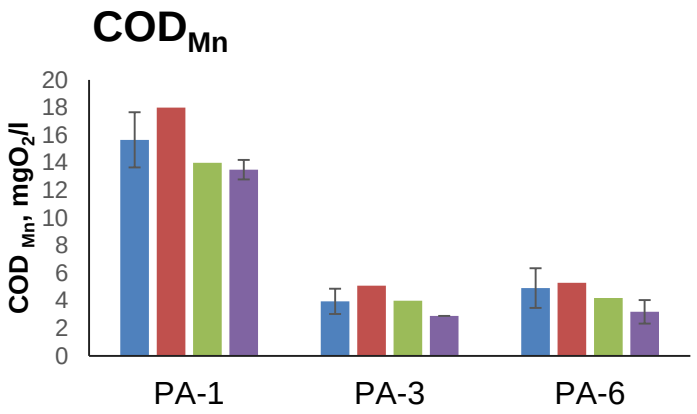
Progress in LFM & conductivity

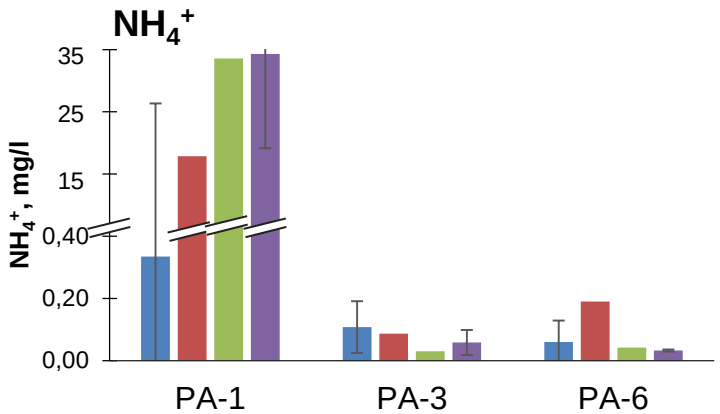


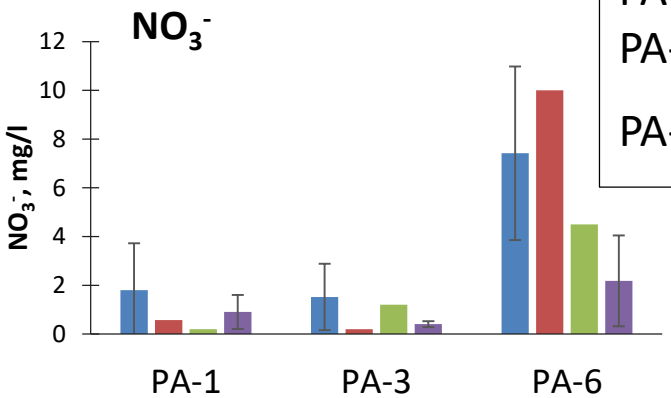
Water quality in groundwater wells

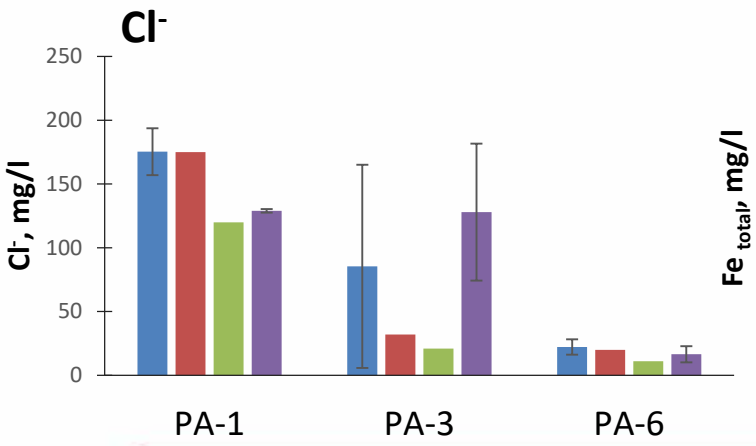
average BEFORE
LFM start
LFM stop
average AFTER

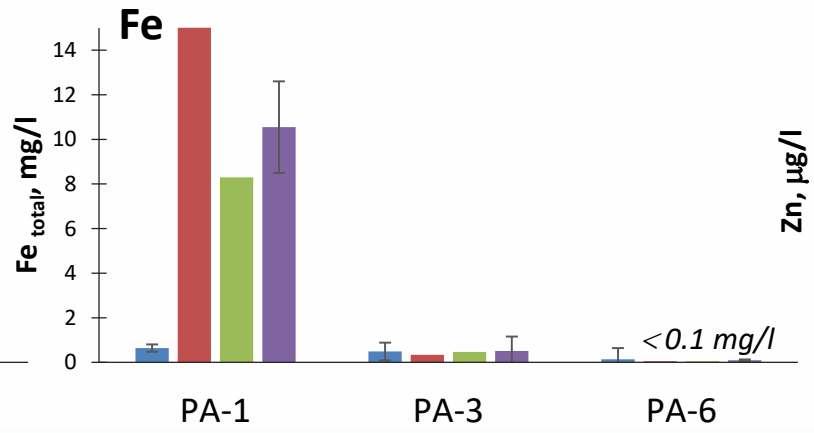
PA-3 upstream
PA-1 downstream
PA-6 far downstream

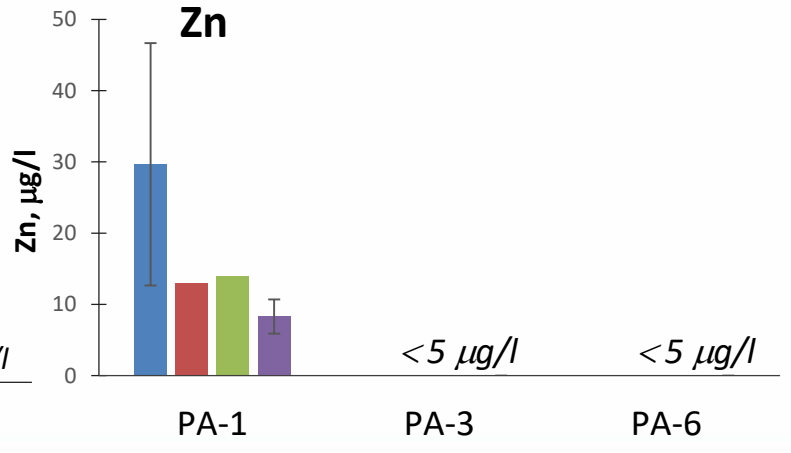












under LoQ:	Hg	Cd	Cr	Cu	Pb	Mo	Sn	Se	phenols	benzene
LoQ (µg/l):	0.04	0.4	2	3	3	2	5	5	0.05	0.01

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Conclusions

- Precipitation increases the volume of water that infiltrates
  - Measure GW levels in boreholes!
- Conductivity is a quick indicator to detect pollution
  - Only a few peak-readings were recorded
- Most affected borehole – direct downstream PA-1 (as expected);
  - However, the effect reduced by distance to PA-6
- Increase was recorded – COD; NH_4^+; Cl^-; Fe
- Heavy metals were stable, most under limit of quantitation
- No significant release of organic pollutants

Conclusions

- Progress in LFM was strongly affected by precipiation
  - Rain = no progress, all works stop.
- Pay attention to hydrology & groundwater flow
  - Establish monitoring network
- Collect stormwater by open ditches
- Consider building constructed wetlands to primarily treat stormwater
  - Be it temporary
- Consider preventive measures to reduce the amount of stormwater
  - Minimise excavated area; back-fill and final cover ASAP

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Grazie!

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