



FINAL CONFERENCE,
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SOIL-GAS MONITORING:

- ➔ Soil-gas sampling installations
- ➔ Soil-gas sampling techniques



INTERREG IV B



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Contents of the presentation

- ◆ Introduction to soil gas sampling/monitoring :
- ◆ Soil gas well design : temporary/permanent/multilevel soil gas well design with focus on multi depth soil gas sampling installations
- ◆ Soil gas sampling techniques : Soil gas purge monitoring, sampling and field tests and main results
- ◆ Recommendations for the choice of the design and gas sampling methods

Context of the study

Different goals of soil gas sampling

- ➡ Source screening, characterization
- ➡ Gas plume delineation
- ➡ Soil gas monitoring

Many reports and recommendations available, but few guidelines dedicated to :

- ➡ soil gas well installation
- ➡ choice of the soil gas well design for multi-depth sampling
- ➡ Case study of the test of multi-depth soil gas sampling with the comparison of the results for the chlorine solvents

- ➡ Review of guidelines, set up of a protocol for the comparison of multi-depth soil gas design and sampling techniques

Soil gas sampling installations -

2 kinds of soil gas characterization/surface emission fluxes

- ◆ **Surface flux sampling** : measure soil gas transfer from the vadose zone to the ambient air : soil gas sample recovered is diluted, specific to an area. The static surface flux chamber and dynamic surface flux chamber could be used.

- ◆ **In situ soil gas sampling** : measure soil gas in equilibrium with a specific soil depth and a dynamic sampling strategy (purge/pumping). Different choice of soil gas well installation and sampling :
 - ◆ Main documents dedicated : ASTM D 5314-92, VDI 3865-2, ISO 10381-7
 - ◆ Two different types of installations : temporary or permanent soil gas installation



Dynamic surface flux chamber

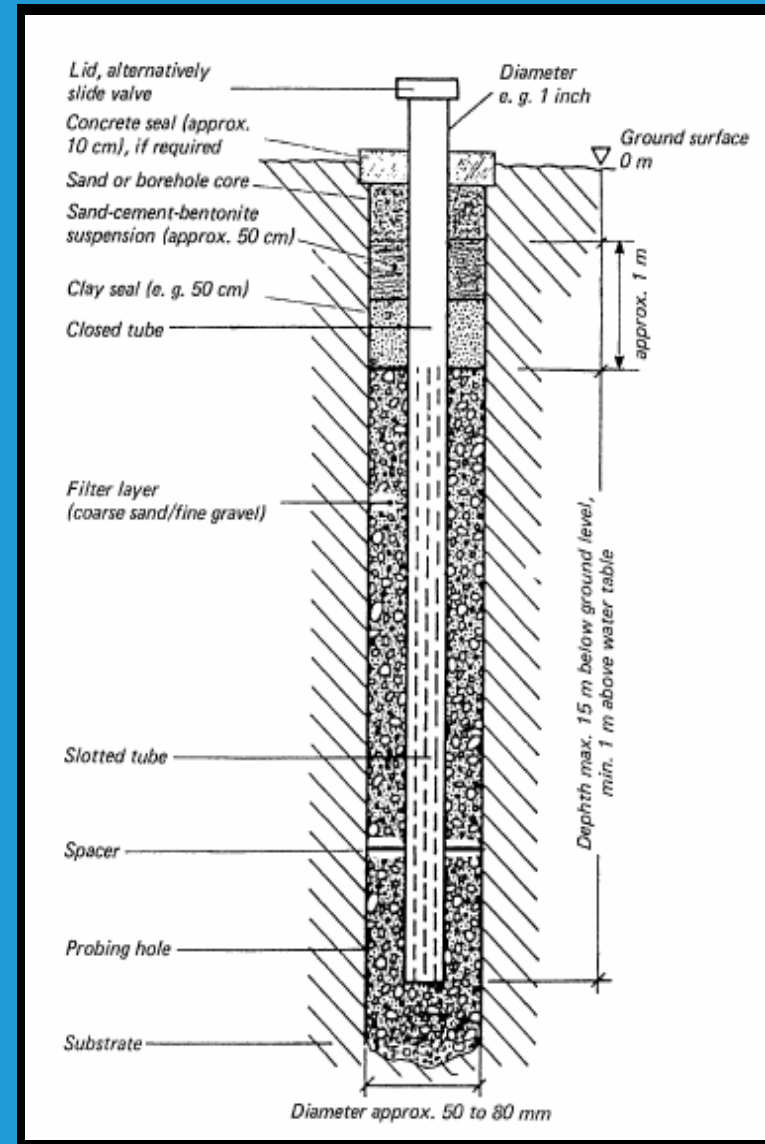


❖ Conventiounal soil gas well design:

- borehole diameter about 60, 80 or 120 mm
 - equipment:
 - closed tube
 - slotted tube
- } material depending on contaminants
- sand/cement/bentonite suspension
 - bentonite or clay seal
 - filter layer (sand or fine gravel)

soil gas well particularities

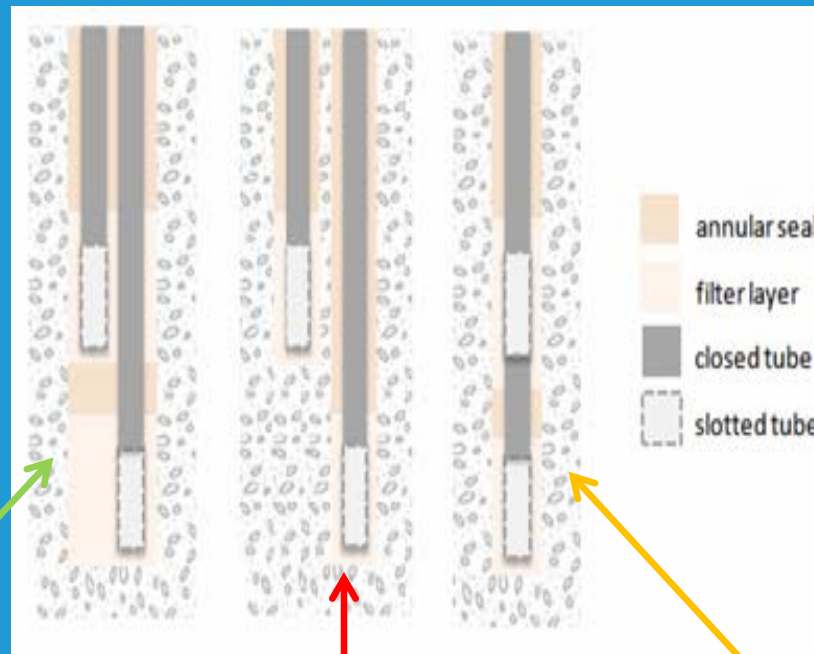
- top of slotted tube at 50 cm deep (at least)
- bottom of slotted tube at 50 cm over the water table





❖ Multi-depth soil gas well design:

- Same particularities than conventional soil gas sampling well
- Various designs for multi-depth soil gas sampling:



two soil gas wells,
implemented in the
same borehole

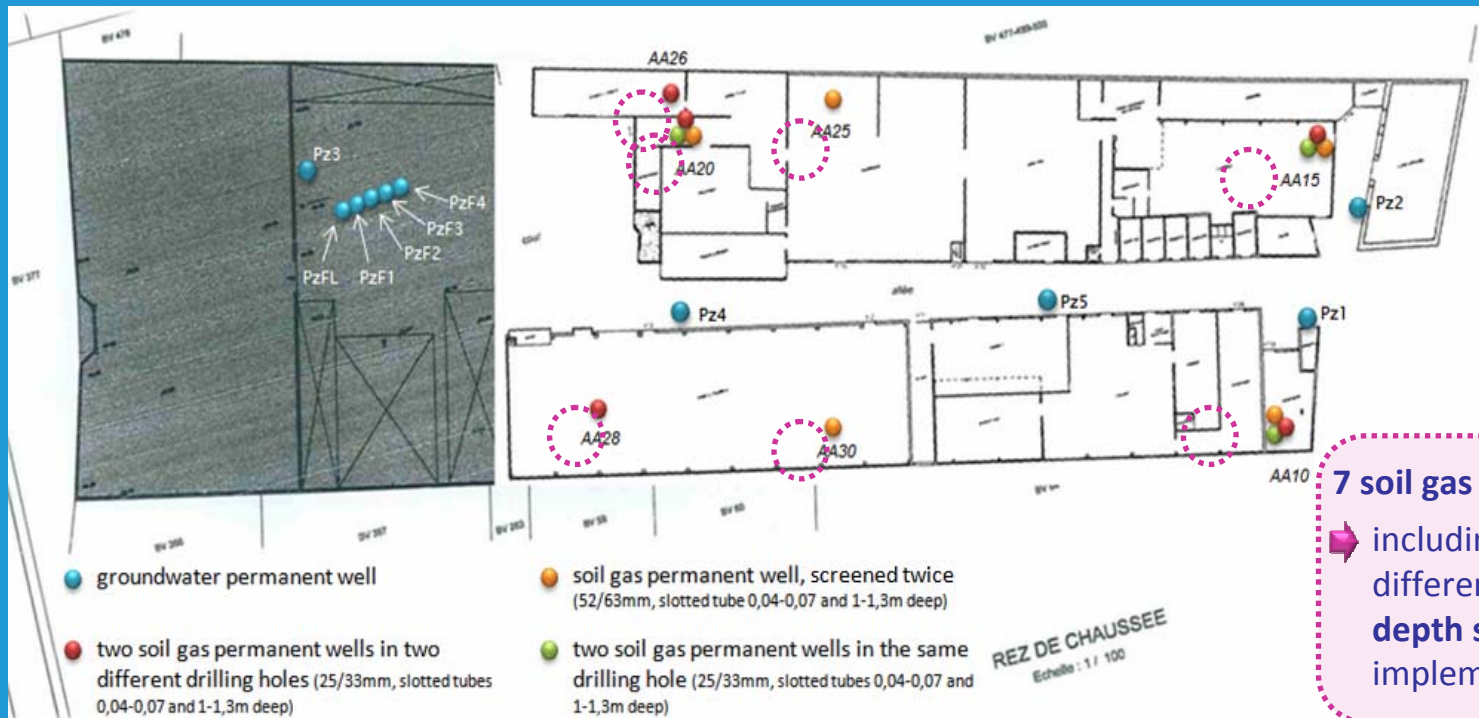
two soil gas wells,
implemented in
different boreholes

soil gas well,
screened twice



❖ Characteristics of the pilot site:

- ➡ located in an urban area
- ➡ chronic contamination with chlorinated solvents (TCE, PCE)



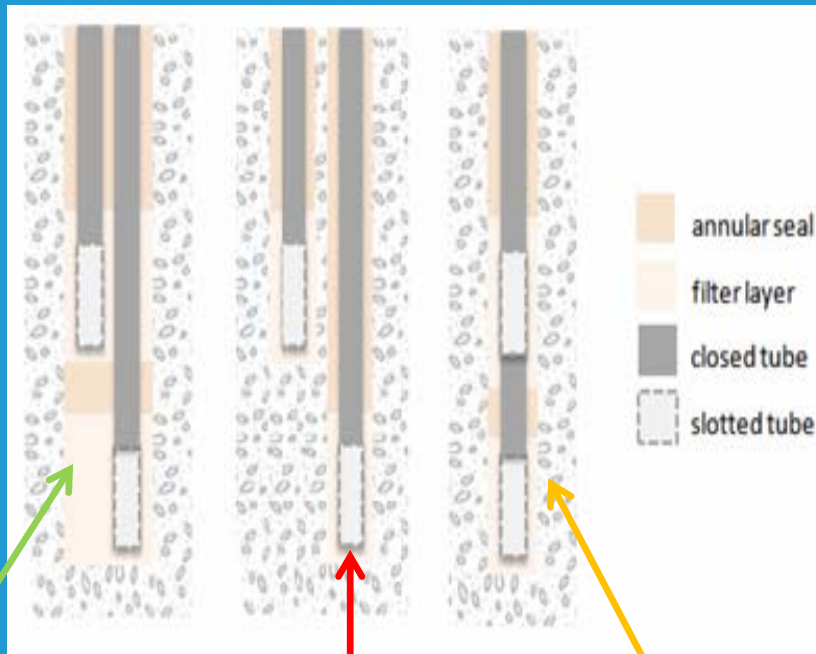
7 soil gas sampling locations, including 3 locations where different designs of multi-depth soil gas wells are implemented

Tests on the pilot site



Tests with 3 different designs:

- ➔ implemented at the same location,
- ➔ on a circle perimeter.

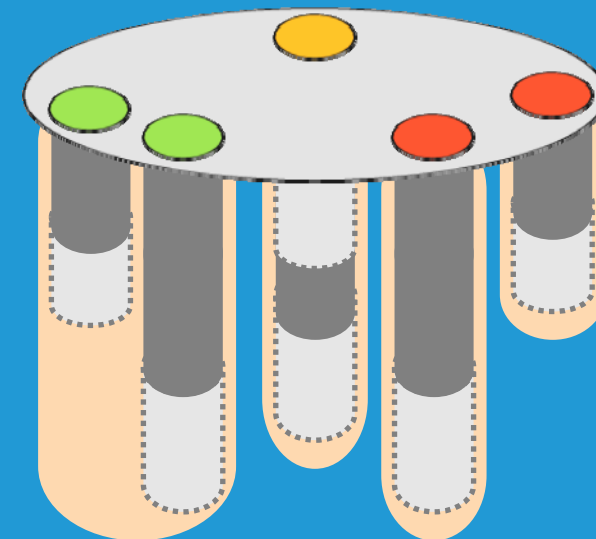


two soil gas wells,
implemented in the
same borehole

two soil gas wells,
implemented in
different boreholes

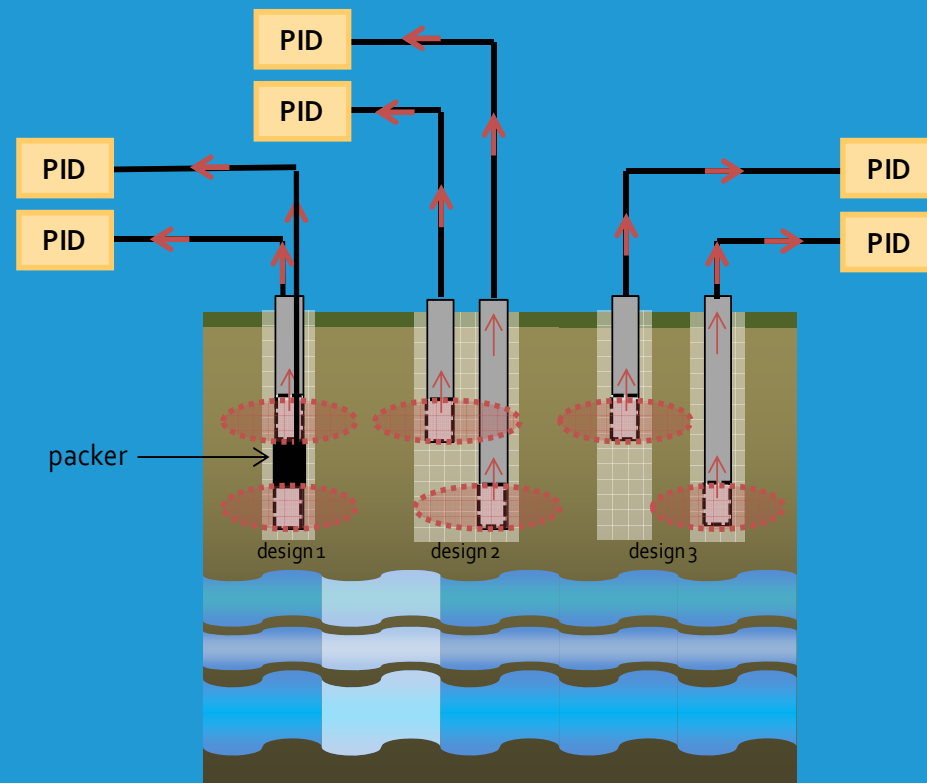
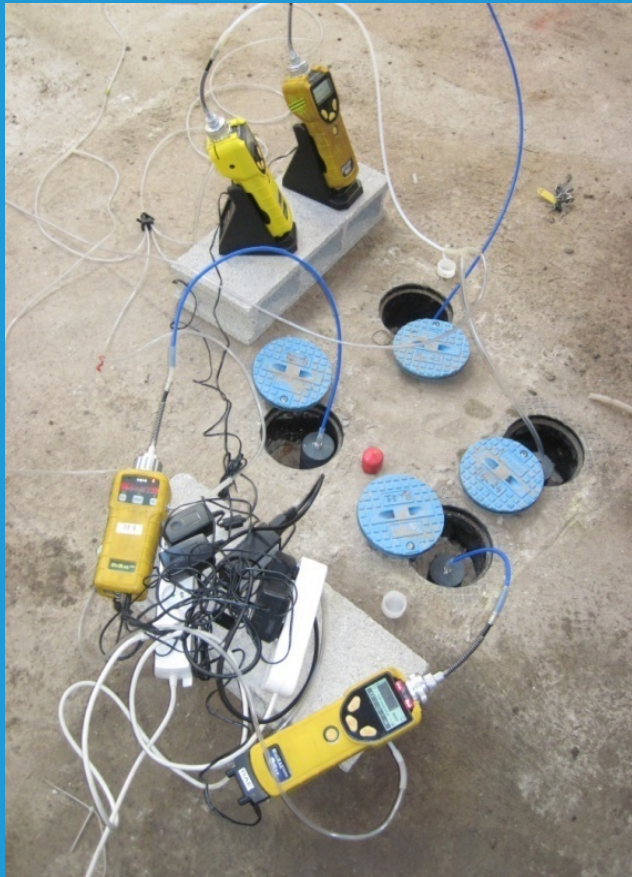
soil gas well,
screened twice

sort of soil gas well	intern diameter (mm)	extern diameter (mm)	depth (m)	screened interval (m)
twice screened	52	63	1,3	0,4-0,7 1,0-1,3
once screened	25	33	0,7	0,4-0,7
Once screened	25	33	1,3	1,0-1,3



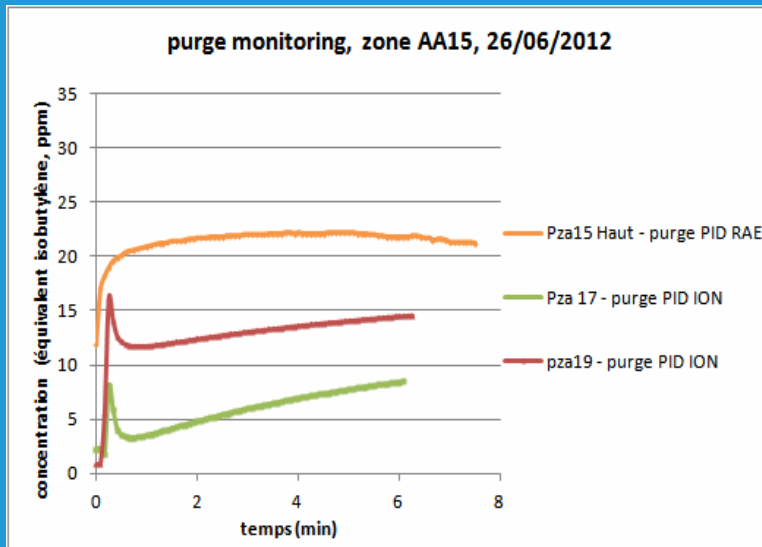
Soil gas well purge monitoring

➡ PID monitoring during the purge

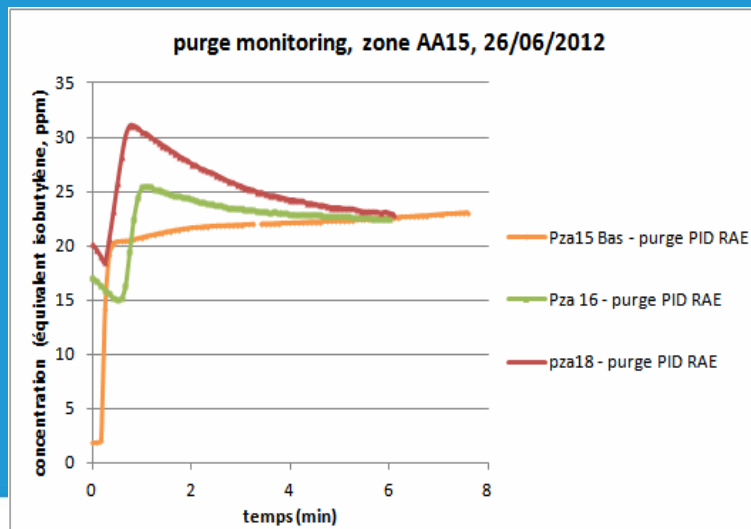


Results

0,4-0,7m
deep



1-1,3m
deep



Standard Sampling Protocol

- Soil gas well purge ($100 \text{ mL}\cdot\text{min}^{-1}$, 5 min) with PID monitoring
- Active soil gas measurement using charcoal sorbent tubes (exposition: 1 hour)
- PID measurement when the sampling ends

SOIL-GAS SAMPLING TECHNIQUES

⇒ Overall goal of soil-gas sampling

🔥 Qualitative characterization :

- source screening,
- gas plume delineation,



- reactive tubes (more or less specific)
- PID, FID
- passive samplers

🔥 Quantitative characterization :

- source and plume characterization (*diagnostic, risk assessment...*),
- soil-gas monitoring (*long-term monitoring, remediation monitoring*),



- active samplers with mechanic pumping
- active samplers using natural suction
- passive samplers (*not used in the frame of this project*)

Choice should be lead by



site specificities (vadose zone, contaminants properties, chemical and biological vadose zone properties...) and **their level of understanding**



investigations objectives



Only few guidelines dedicated (to soil-gas well installations) and soil-gas sampling methods have been published

SOIL-GAS SAMPLING TECHNIQUES

➔ Quantitative characterization techniques

🔥 Active samplers using natural suction

➔ sampling device : **stainless steel container** (ex: Summa-Canister®)

Main advantages

- particularly helpful when extreme concentrations (both high and low concentrations)
- several compound families could be analyzed on the same sample of air (HVOCs, BTEX...)
- not breakable
- autonomous (do not need pump)

Main limitations

- sensitive to humidity (*high humidity level measured in soil gas wells*)
- cleaning and maintenance protocols



Summa-Canister (6 L, suction rod and veriflow system)
(source: INERIS)

SOIL-GAS SAMPLING TECHNIQUES

⇒ Quantitative characterization techniques

🔥 Active samplers using mechanic pumping

➔ sampling devices :

- ❖ sample bags (*not used in the frame of CityChlor*)
- ❖ sorbent tubes: containing one or several **adsorbent beds** (carbon or resin-based polymers), depending on the targeted compounds



activated charcoal

sampling parameters

- soil-gas volume,
- pump flow (should be calibrated and checked)
- sampling duration
- the adsorption capacity of the sorbent
- the targeted limit of quantification

Main limitations:

- humidity (depending on the adsorbent)
- needs of electricity (if long sampling duration)



- saturation problems if concentration ranges are not well-known

SOIL-GAS SAMPLING TECHNIQUES

⇒ Quantitative characterization techniques

◆ **Additional measurements recommended for better data interpretation**

➤ **meteorological conditions (influencing gas transfer)**

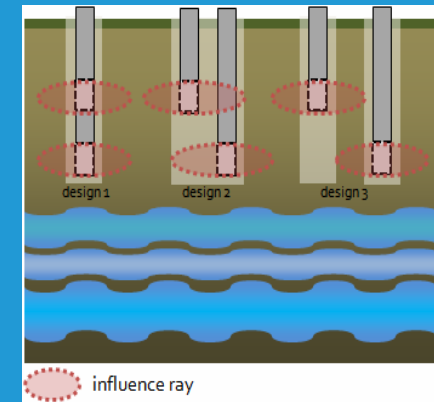
- ❖ **pressure monitoring (soil-gas, indoor as well as barometric pressure),**
- ❖ **temperature (indoor and outdoor buildings),**
- ❖ **wind speed**
- ❖ **rainfall**
- ❖ **humidity in soil gas**
- ❖ **water table depth monitoring in the groundwater wells**
- ❖ **several sampling campaigns carried out under different weather conditions (winter/summer)**

TESTS CARRIED OUT AND RESULTS

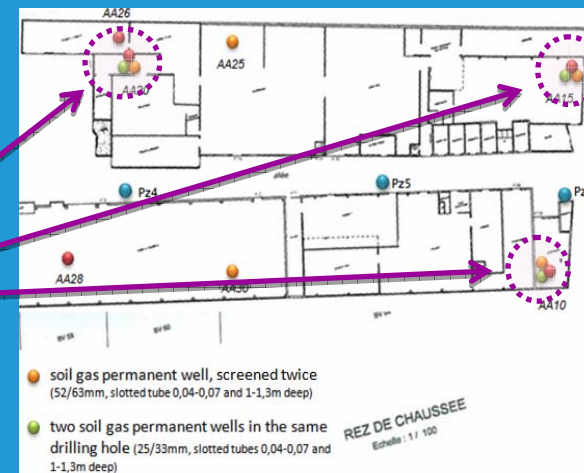
➔ Tests carried out and results

🔥 from the soil-gas sampling results, different comparisons depending on:

- ➔ meteorological conditions
- ➔ sampling location
- ➔ sampling depth (0.4-0.7 or 1.0-1.3 meters deep)
- ➔ soil-gas well design



three different locations
(AA10, AA15, AA20)

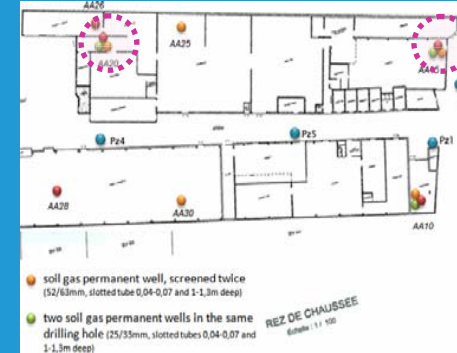
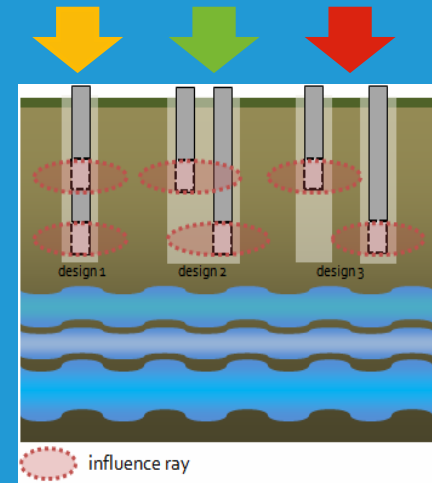
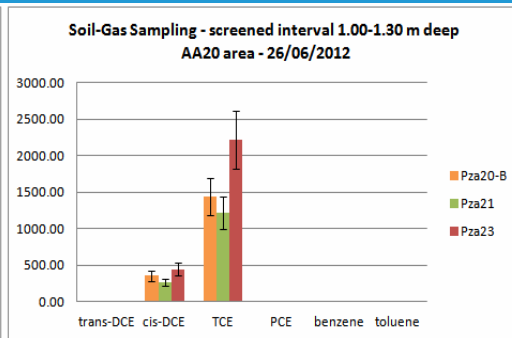
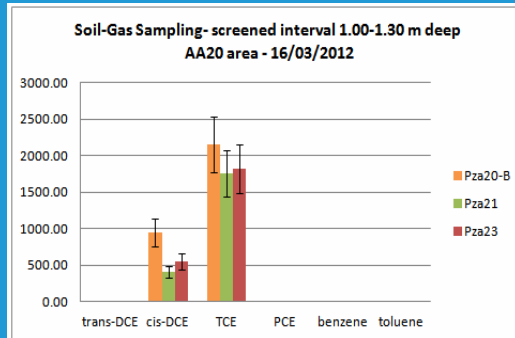
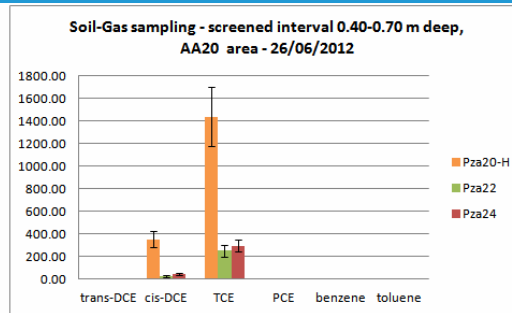
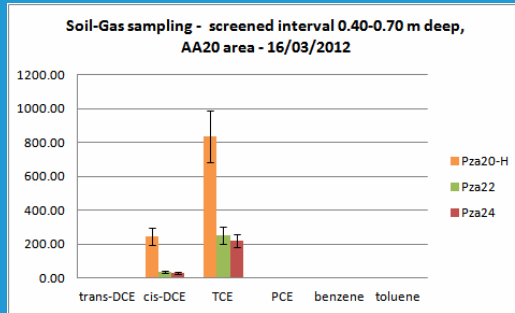


TESTS CARRIED OUT AND RESULTS

➔ Tests carried out and results

🔥 Comparison of results obtained in different soil-gas well designs

↪ soil-gas concentrations (mg/m^3) measured at the same depth in different well designs, using sorbent tubes (activated charcoal)



TESTS CARRIED OUT AND RESULTS

⇒ Tests carried out and results

● Comparison of results obtained in different soil-gas well designs



soil-gas concentrations (mg/m³) measured at the same depth in different well designs, using sorbent tubes (activated charcoal)

Main conclusions:

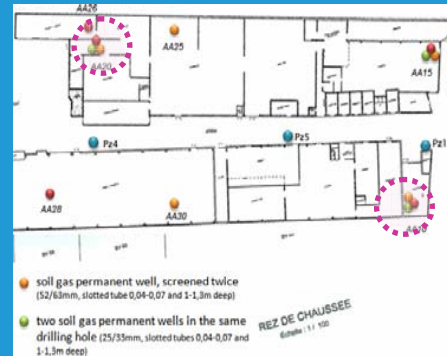
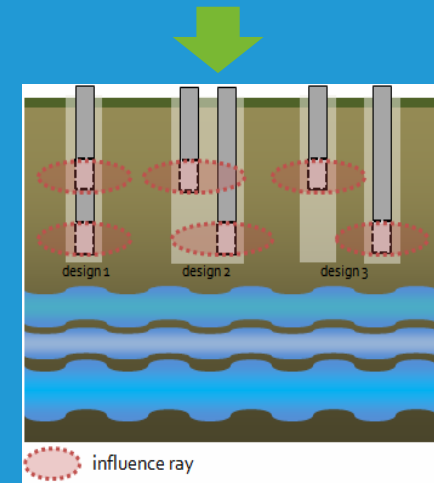
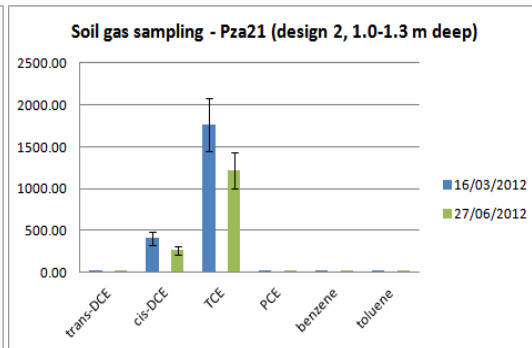
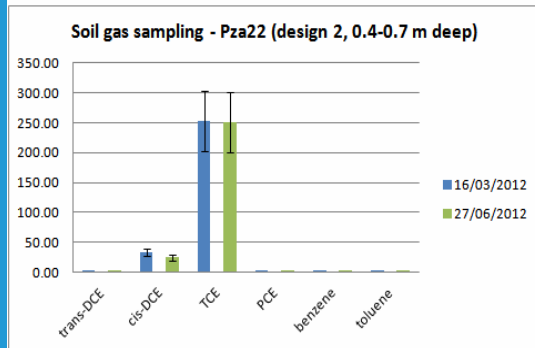
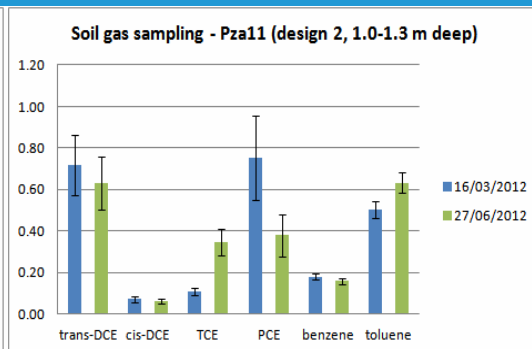
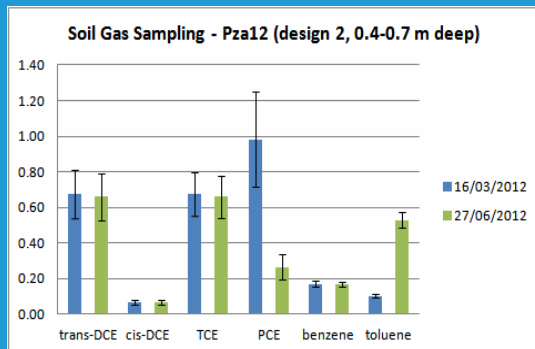
- all the concentrations are of the same size of order (except one case)
- design 2 and design 3 soil gas wells give similar results
- design 1 over values contaminant concentration in embankments (screened interval 0.40-0.7 m deep)
 - ↪ due to packer?

TESTS CARRIED OUT AND RESULTS

➔ Tests carried out and results

🔥 Comparison of results obtained in different soil-gas well designs

➔ soil-gas concentrations (mg/m³) measured at two different periods, using sorbent tubes (active charcoal)



GENERAL CONCLUSIONS

- 🔥 the **appropriate** soil-gas sampling technique depends on:
 - investigation objectives
 - site specific constraints
 - targeted substance
 - different levels of contamination

- 🔥 some **delicate** and important sampling “**steps**”
 - soil gas installation purge
 - in case of mechanical suction sampling techniques : pump calibration
 - storage and transport conditions

- 🔥 **additional measurements** recommended for better data interpretation
 - meteorological conditions, an important impact on contaminants transfer

- 🔥 **according to the results obtained in the frame of CityChlor project**
 - **two soil-gas well designs can be recommended for multi-depth sampling: multi-depth nested wells and soil-gas wells installed in different but similar boreholes**
 - **soil-gas well with two screened intervals should be considered only if packer airproof could be well-mastered**