



# Passive samplers as an innovative way for groundwater quality monitoring

Julien Michel / Marie Lemoine / Pauline Molina / Francis Guillot / Fabrice Richez

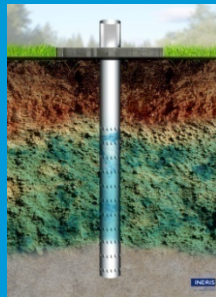


- ◆ Context of the study and definition of passive sampling
- ◆ Experiments on site: design of the tests
- ◆ Recommendations for the use of passive samplers for groundwater quality measurement

## Overall goal of groundwater sampling

- ➡ to get a « **representative** » sample (as regard to the groundwater quality near the sampling point)

## In general (conventional sampling method)



- ➡ Time consuming, large volume of water to be treated, average concentration (weighted by the flow)
- ➡ How to sample groundwater without purging the well and to get a representative sample?

## Passive samplers

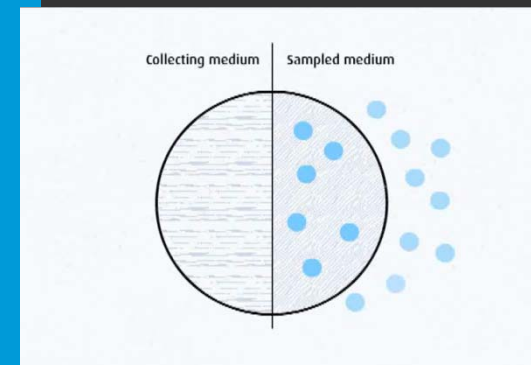
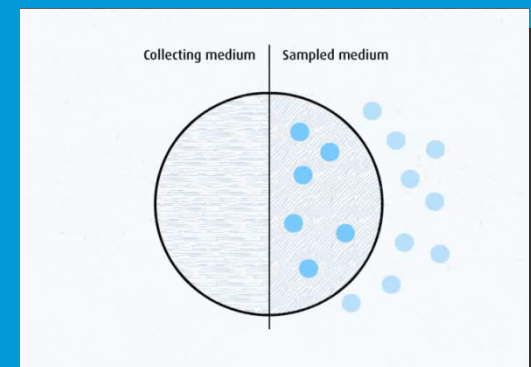


- ➡ Groundwater: “one that is able to acquire a sample from a discrete location or interval in a well without the active transport associated with a pump or purge technique” (ITRC, 2007)
- ➡ When no vertical flow in the well: depth discrete sampling possible

# Passive sampling - Definitions

## 3 kinds of passive samplers

- ◆ **Grab samplers**: sample recovered is an instantaneous representation of conditions at the sampling point, at the time of sample collection, without purging
- ◆ **Diffusion samplers**: compounds of interest reach and maintain equilibrium via diffusion through a membrane (sample is an instantaneous representation of the conditions at the time of sampler retrieval, at the sampling point)
- ◆ **Integrative samplers**: rely on diffusion and sorption of the contaminants which accumulates in the sampler (results are an average concentration of the contaminant over the exposure time)



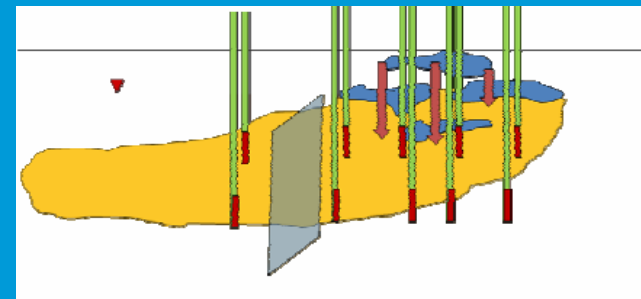
# Tests on passive samplers

➤ Design of the tests

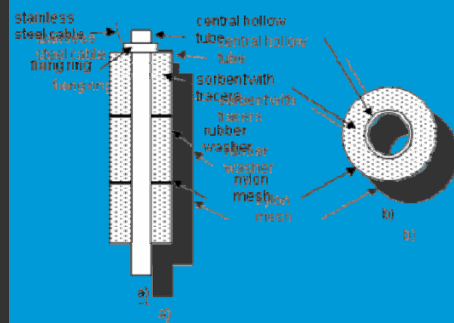
## Pilot project "Utrecht"

Passive flux measurement (mass per unit time per area)

- ◆ concentrations in groundwater
- ◆ flow rate
- ◆ surface area through which contaminants flow
- ➡ combination of time-average concentration, flow rate and flow direction

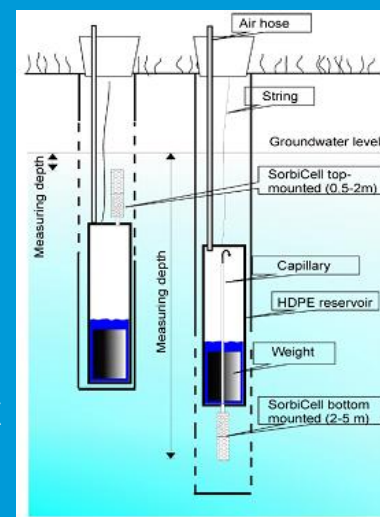


## ➡ 3 passive samplers



SorbiFlux

- ➡ Used to calculate the flux



SorbiCell

- ➡ Used to calculate the flux

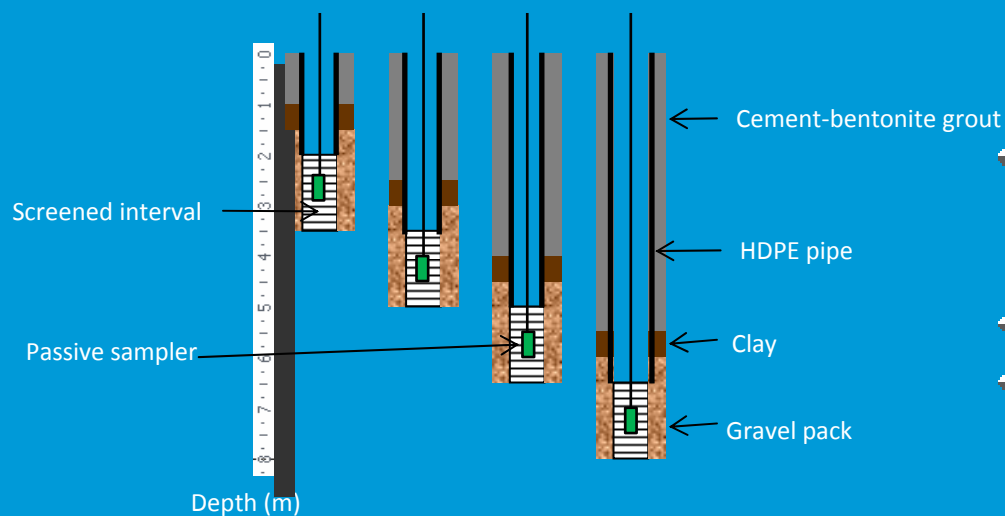
Passive flux meter (PFM)

- ➡ Flux directly measured

# Tests on a pilot site

## Pilot project “Ile de France”

- ➡ Groundwater: contamination with HVOC and trace metals
- ➡ 4 dedicated wells



### ◆ Concentration ranges :

PCE: 60 – 4 000  $\mu\text{g/L}$  ; TCE: 80 – 1 800  $\mu\text{g/L}$

Cis-DCE: 4 500 – 8 000  $\mu\text{g/L}$  ; VC: 100 – 4 000  $\mu\text{g/L}$

### ◆ Comparison with the pump, reproducibility

### ◆ One sampler in the middle of each screened interval

- ➡ 4 passive samplers



PDB



Dialysis membrane



Ceramic dosimeter



Gore Sorber  
Module

## Recommendations

- Passive sampler selection
  - Passive sampler set up
  - Data interpretation
- for groundwater quality measurement



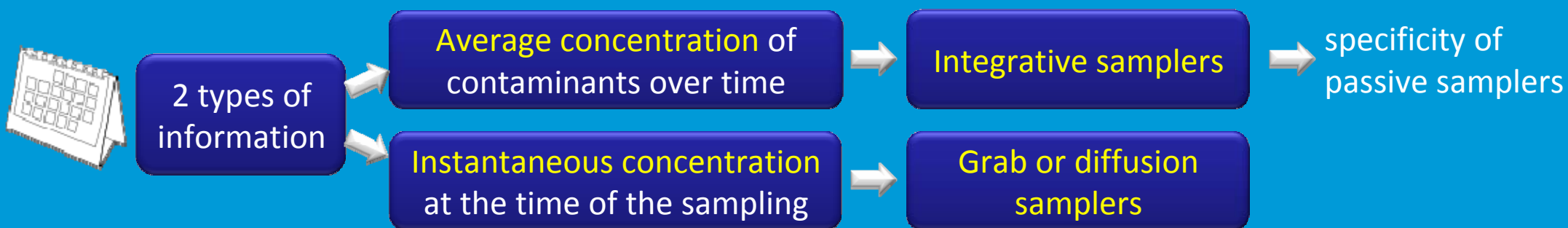
# Passive sampler selection

## Aim of the study

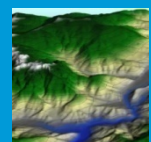
On a site already characterized (e.g. groundwater monitoring)

➡ evolution of contaminant concentration over space and time

## Aim of the monitoring in time



## Aim of the monitoring in space



- ◆ Vertical distribution
- ◆ Concentration at the surface of the water table

Grab, diffusion or integrative samplers  
(aim of the monitoring in time)

- ◆ Monitoring of a plume migration
- ◆ Using passive samplers as warning points

Integrative samplers in general

## Compounds to monitor

➡ most of passive samplers: contaminant-specific

## General installation and retrieval: knowledge of the monitoring network

- ➡ borehole diameter, screened interval position and length, variation of the groundwater level over time

## Type of samples to collect: knowledge of the local hydrogeology

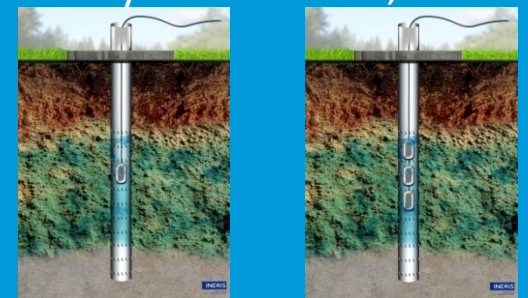
- ◆ Natural vertical flow in the well (especially for depth discrete or multi level sampling)
- ◆ Water production of soil horizon

## Exposure time: passive sampler type and concentration ranges

- ◆ Diffusion samplers: equilibrium should be achieved and system back to “normal” conditions
- ◆ Integrative samplers: long enough to reach the quantitation limit of the analytical method, not too long in order not to saturate the adsorbent
- ➡ given by the manufacturer

## Number and position of passive samplers

- ◆ Screened intervals < 1.5 m: in the middle of the screened interval
- ◆ Screened intervals > 1.5 m: measurement of natural vertical flows
  - ➡ natural vertical flows: depth discrete sampling not possible / sampler anywhere in front of the screened interval



➡ measurement of natural flows: depth discrete sampling not possible / sampler anywhere in front of the screened interval

**Side by side comparison test with the conventional sampling technique for a given well (at least at the beginning)**

Passive sampling prior to conventional sampling (to avoid disturbances in the well)

## Sometimes results different

- ◆ Different principles of operation / sometimes access to different information
- ◆ For example, if concentrations given by passive samplers > concentrations from pumping
  - ➡ passive samplers at the most contaminated level
  - ➡ for integrative samplers, sampling with the pump when contaminant mass flux is lower

## Main advantages

- ◆ Easy and quick to install and retrieve
- ◆ No external energy source or additional equipment
- ◆ No cross contamination
- ◆ More cost-effective than conventional sampling in general
- ◆ Depth discrete sampling possible, appropriate when access is difficult or discretion desirable, no depth limit

} **Observed in the field!**

## Main limitations of passive sampling

- ◆ When different pollutant classes on site: different samplers needed (except dialysis membrane: HVOC and metals)
- ◆ Good knowledge of hydrogeological conditions at the sampling point needed

## Outputs of the CityChlor project concerning passive sampling

- ◆ Movie presenting passive sampling for groundwater
- ◆ Guideline on the use of passive samplers for groundwater quality measurement: recommendations on how to use passive samplers for groundwater quality measurement
- ◆ Site report "Ile de France" and report "Integration of results, CSM Bio-washing machine": description of the tests on passive samplers



*Thank you for your attention*