



GROUPE RENAULT

STRATEGY OF A CONTAMINANT SOURCE LOCALISATION WITH INVERSE MODELLING AND INNOVATIVE MEASUREMENT

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METHODOLOGY

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CONTAMINANT SOURCE LOCALISATION

 \Rightarrow Real challenge

Complex due to

- Site heterogeneity
- Unknown contaminant history
- Limited number of wells
- High cost





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CONTAMINANT SOURCE LOCALISATION

Initial data : concentrations value

- Unknown and heterogeneous

hydraulic conductivity K field

- Unknown dispersivity

 \Rightarrow 3 different scenario

Solution :

- Inverse modelling
- Mass flux measurement







Scenario 3



CHALLENGES

Development of a practical source localisation strategy for real case studies

- Working with unknown hydraulic and transport parameters
- Using a non-linear optimisation method for parameters estimation
- Consideration of a continuous source (stabilized plume)
- Addition of a limited number of observations

 \Rightarrow To reduce uncertainties on the source location

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CHOSEN APPROACH

- 1. GLMA : Gauss Levenverg Marquardt Algorithm
- Non-linear optimisation with PEST++ code

(Doherty, 2010)

- Simulation with Modflow and Mt3dms
- Initial observed data : Concentration C + Hydraulic head H
- Parameters estimation
- \Rightarrow Hydraulic conductivity field : K field
- \Rightarrow Dispersivity : α
- \Rightarrow Source localisation : coordinate Ys (Xs fixed)

- 2. Data worth analysis
- PYEMU (White et al., 2016)
- ⇒ New data sets to reduce
 uncertainty of a forecast
 (source position)
- \Rightarrow Identify the best location of new observations

4



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ITERATIVE METHOD



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PHASE 1 – INITIAL STATE







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PHASE 1 – GLMA RESULTS

- Ys = 642 <u>+</u> 14 m
- RMSE _c = 1.2 μ mol/L (NRMSE < 15%)
- RMSE _H = 0.06 m (NRMSE < 5%)

*RMSE = Roots Mean Square Deviation

*NRMSE = Normalized RMSE





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PHASE 1 – DATA WORTH ANALYSIS

Constraints for new observations

- Accessible zone for drilling
- High value in the map uncertainties
- Avoid redundant observation

Chosen new observations

- First point : F7
- Second point : P30 (existing well)
- Third point : F6

8

- Fourth point : F5 (accessible zone)



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PHASE 2 – INITIAL STATE



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PHASE 2 – GLMA RESULTS

- Ys = 634 ± 3.7 m (642 ± 14 m in Phase 1)
- RMSE _c = 2.5 μ mol/L (NRMSE < 15%)
- RMSE_H = 0.08 m (NRMSE = 5%)





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PHASE 2 – ESTIMATED K FIELD

1 source was localised but :

• Piezometric map and K field present anomalies

Solution :

• Improve the site characterisation

Mass flux study ← INDIRECT Darcy flux + Concentration



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CSM IMPROVEMENT WITH INNOVATIV TOOLS

Mass flux = q x C $[\mu mol/m^2/day]$

• Direct Velocity Tool (Essouayed et al., 2019)

 \Rightarrow Darcy flux measurement : **q** [m/jour]



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Review papers

An innovative tool for groundwater velocity measurement compared with other tools in laboratory and field tests



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• Targeted sampler

 \Rightarrow Concentration measurement : **C** [μ mol/L] **12**



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CSM IMPROVEMENT WITH INNOVATIV TOOLS

DVT and Targeted Sampler combined

- COV sum
- 2 plumes ?
- \Rightarrow North : F7 et P29 impacted
- \Rightarrow South : F5 and F2 impacted

Hypothesis

2 ZONES OF INDEPENDANT MASS FLUX



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PHASE 3 – GLMA RESULTS

- Ys1 = 624 \pm 8 m and Ys2 = 533 \pm 6 m
- RMSE _c = $1.9 \,\mu mol/L$ (NRMSE < 15%)
- RMSE $_{\rm H}$ = 0.08 m (NRSME = 5%)



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PHASE 3 – ESTIMATED K FIELD

Results

- 2 sources localised (north and south)
- \Rightarrow Mass flux measurement
- \Rightarrow GLMA

K field

 \Rightarrow No anomaly



PHASE 2 VS PHASE 3 - DARCY FLUX COMPARISON



STRATEGY VS GEOPROBE AND HISTORICAL SOURCES



High resolution measurement and potential historical sources

Geoprobe © (MIP + HPT) :

- Realised before the strategy
- Transect (red) in the South part of the zone
- Results only available at the end of the study

Historical sources

- Brown rectangles
- Numerous and extensive

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STRATEGY VS GEOPROBE AND HISTORICAL SOURCES



CONCLUSIONS

Synthesis and learning

- Strategy developed in synthetic cases first and in a real active industrial site
- \Rightarrow Requirement of a small number of wells
- Combination with an expert vision
- \Rightarrow Improvement of the CSM with mass flux measurement (DVT + concentration)
- \Rightarrow Using Geoprobe and the potential historical pollution

Openings

- Test the strategy for different context
- Economic study of the strategy developed
- Develop a decision tool for source localisation

combining inverse modelling and in-situ

measurement to minimise uncertainties on a

source location



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Thank you for your attention