Flux-controlled Remediation & Risk Management: Strategy and Examples

2pm, 6th March 2019
Goedele Verreydt
Co-founder and CTO of iFLUX

Goedele is the inventor of the iFLUX technology and expert in terms of flux sampling of soil and groundwater contamination. Goedele has both gained experience in the consultancy sector as a remediation consultant, as well as in the research world, where she has not only led PhD research, but was also responsible for the entire iFLUX development process.

Chair – Ian Grant - Editorial Director - Environment Analyst’s Development + Infrastructure Service
Today’s Speakers

Tim Op ‘t Eyndt
Co-founder and CEO of iFLUX

Tim is co-founder of iFLUX. The spin-off company of the Flemish Research and Technology Organisation (VITO) and the University of Antwerp was founded in 2017 but had a long history of several research and development projects to create the unique iFLUX technology.

Chair – Ian Grant - Editorial Director - Environment Analyst’s Development + Infrastructure Service
Webinar Aims

This webinar will explore:

• How flux measurements deliver accurate and essential information for groundwater research & management

• How to determine remediation urgencies and priority source zones

• Benefits of mass flux in remedial design and the monitoring of remediation efficiency
Questions

Please submit your questions during the webinar using your chat box.

If you have any unanswered questions please email matthew.abbott@environment-analyst.com, following the webinar.
Benefits of mass flux in remedial design and the monitoring of remediation efficiency

Goedele Verreydt
co-Founder & Technical Director iFLUX

Tim Op ‘t Eyndt
co-Founder & Managing Director iFLUX
Dynamics of soil and groundwater pollution often is underestimated.
Mass flux concept

mass discharge

mass flux = \frac{mass}{area \times time}
Contaminant mass fluxes can vary.
Contaminant mass fluxes can vary
Mass flux concept

**Mass Flux** (J) = qC = KiC

<table>
<thead>
<tr>
<th>Material</th>
<th>K (m/day)</th>
<th>i (m/m)</th>
<th>C (μg/L)</th>
<th>Mass Flux (g/m²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Sand</td>
<td>1.0</td>
<td>0.003</td>
<td>10,000</td>
<td>0.03</td>
</tr>
<tr>
<td>Gravelly Sand</td>
<td>33.3</td>
<td>0.003</td>
<td>10,000</td>
<td>1</td>
</tr>
<tr>
<td>Sand</td>
<td>5.0</td>
<td>0.003</td>
<td>10,000</td>
<td>0.15</td>
</tr>
</tbody>
</table>
New versus old contamination

- Historical contamination with exhausted source
- Mass discharge is reduced with 95%

Mass Flux \( J = K_i C \)

- **Gravelly Sand**
  - Source Zone
  - Fine Sand: 3%
  - Gravelly Sand: 85%
  - Sand: 12%
  - Historical contamination with exhausted source
  - Mass discharge is reduced with 95%

- **Residual Source**
  - Fine Sand: 70%
  - Gravelly Sand: 12%
  - Sand: 18%

- **Zone**
  - Gravelly Sand: 85%
  - Fine Sand: 3%
  - Sand: 12%

- **Mass Flux Calculations**
  - **Gravelly Sand**
    - \( K = 1.0 \text{ m/day} \)
    - \( i = 0.003 \text{ m/m} \)
    - \( C = 10,000 \mu g/L \)
    - Mass Flux = 30 mg/m²/day
  - **Gravelly Sand**
    - \( K = 33.3 \text{ m/day} \)
    - \( i = 0.003 \text{ m/m} \)
    - \( C = 50 \mu g/L \)
    - Mass Flux = 5 mg/m²/day
  - **Gravelly Sand**
    - \( K = 5.0 \text{ m/day} \)
    - \( i = 0.003 \text{ m/m} \)
    - \( C = 500 \mu g/L \)
    - Mass Flux = 7.5 mg/m²/day
iFLUX technology

We are able to perform a direct flux measurement

- Patented and validated
- Captures 90% of all pollution types
- Accurate measurement of speed and direction
- Potential cost reduction up to 30%
Calculation of the fluxes

Darcy water flux
\[ q_0 = f (m_t, \alpha) \]

Contaminant mass flux
\[ J_c = f (m_c, \alpha) \]
Flux results

End report with interpreted and analysed flux results.

Well depth graph
Each sampler location delivers accurate flux results for each depth

Control plane
Interpolation technique to calculate and visualize spreading of groundwater and pollution
When to apply flux measurements?

- More accurate characterization
- Design remediation plan
- Remediation urgencies and priority ranking
- Follow up of remediation efficiency
- Monitoring of Natural Attenuation
- Risk-based groundwater management

Flux sampling offers more certainty!
Field cases
Case 1: Spreading of a CAH plume to the Seine

- Volatile hydrocarbons
- Accurate risk of spreading
- Determine total mass discharge
- 50 samplers, 6 cartr./sampler
- Near tidal river

Partner: Burgeap
Project: Evaluation and spreading of a CAH plume
Case 1: Spreading of a CAH plume to the Seine

- Volatile hydrocarbons
- Accurate risk of spreading
- Determine total mass discharge
- 50 samplers, 6 cartr./sample
- Near tidal river

Company: Burgeap
Project: Evaluation and spreading of a CAH plume
Case 2: Spreading of a VOCI plume to the Zenne

✓ VOCIs
✓ Vilvoorde-Machelen
✓ Spreading risk
✓ Mass discharge calculation

Company: OVAM
Project: Vilvoorde-Machelen
Case 2: Spreading of a VOC\textsubscript{I} plume to the Zenne

- VOC\textsubscript{I}s
- Vilvoorde-Machelen
- Spreading risk
- Mass discharge calculation

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Risk level ((\mu g \text{ L}^{-1}))</th>
<th>(f_d) [-]</th>
<th>CMD\textsubscript{max,0} (g d(^{-1}))</th>
<th>CMD\textsubscript{max,CP1} (g d(^{-1}))</th>
<th>CMD\textsubscript{CP1} (g d(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>perchloroethylene</td>
<td>10</td>
<td>20.6</td>
<td>8</td>
<td>4308</td>
<td>81</td>
</tr>
<tr>
<td>trichloroethylene</td>
<td>10</td>
<td>20.6</td>
<td>8</td>
<td>4308</td>
<td>81</td>
</tr>
<tr>
<td>cis + trans dichloroethylene</td>
<td>10</td>
<td>2.9</td>
<td>8</td>
<td>4308</td>
<td>11</td>
</tr>
<tr>
<td>vinylchloride</td>
<td>10</td>
<td>1.5</td>
<td>8</td>
<td>4308</td>
<td>6</td>
</tr>
<tr>
<td>benzene</td>
<td>10</td>
<td>20.6</td>
<td>8</td>
<td>4308</td>
<td>81</td>
</tr>
</tbody>
</table>

Company: OVAM
Project: Vilvoorde-Machelen
Case 3: Spreading of a nickel plume

Active site with industry on surface treatment of metals

(Hydro)geology

- coarse sand, gravel
- high permeability
- groundwater at 8m-bgl
- GW flow in South direction, rather low gradient
- 2 GW extraction wells at 29m-bgl – processwater

Partner: Antea Group
Project: Active site with industry on surface treatment of metals
Case 3: Spreading of a nickel plume

Soil contamination

- sludge of former open sedimentation basin for waste water
- ‘source zone remediation’: removal of contaminant load in shallow, unsaturated zone

Partner: Antea Group
Project: Active site with industry on surface treatment of metals
Case 3: Spreading of a nickel plume

Groundwater contamination
- groundwater contaminated with nickel and CVOC’s
- no DNAPL seems to be present in the saturated zone

Further evolution of contaminated groundwater plume?

Partner: Antea Group
Project: Active site with industry on surface treatment of metals
Case 3: Spreading of a nickel plume

- 2 phases of flux monitoring
- Phase 1 (plume): 3 well clusters, 3 depths
- Spreading + natural attenuation potential
- Nickel & chlorinated solvents
- 3 clusters of 3 wells with 2m screen → 3 depths

Partner: Antea Group
Project: Active site with industry on surface treatment of metals
Questions and Answers

If you have any unanswered questions please email matthew.abbott@environment-analyst.com, following the webinar.
Did you enjoy today’s webinar?

Hear Tim, and other industry experts, discuss practical solutions to your Groundwater issues at

Groundwater 2019

27 March, London
Groundwater 2019 returns 27 March to London, offering delegates:

- **Practical advice:** get insight into new strategies, innovations and techniques to help you combat your groundwater challenges

- **Case studies:** learn from hands-on experience in a series of case studies which will provide technical guidance and practical frameworks which can be applied immediately within your organisation

- **Networking:** meet and mingle with other industry professionals, and put your questions to our panel of expert speakers

- **CPD accredited:** this event is CPD certified.

For more information visit www.environment-analyst.com/groundwater-2019
Upcoming Events

• Webinar: EIA Post-Brexit Bounded Speculation, 1pm, 14 March 2019
• EIA Significance Training Course, 25 March, London
• Groundwater, 27 March, London
• Brownfield and Contaminated Land, 1 May, Belfast
• Ground Gas, 9 May, London
• Waste Management, 21 May, London
• EIA Significance Training Course, 16 May, Manchester
• EA Business Summit, 19 June, London
• Site Investigation, 27 June, London

To view our full events calendar visit www.events.environment-analyst.com/
A downloadable recording of this presentation (with slides) will be available shortly.

If you have any questions, please contact Matt –
matthew.abbott@environment-analyst.com