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IBED

How is environmental behaviour of flowback chemicals affected by downhole conditions?

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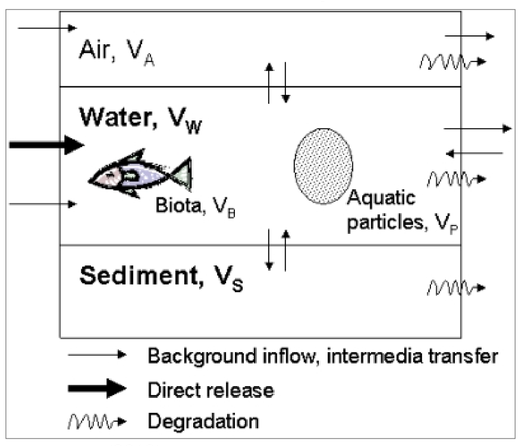
❖ Can current **conceptual box models** adequately **predict environmental fate** of chemicals related to **oil and gas extraction**?

❖ How do **high pressure and temperature** conditions affect **behaviour**?

Introduction[1,2]

Current conceptual box models are based on ...

➢ Surface/shallow exposure routes



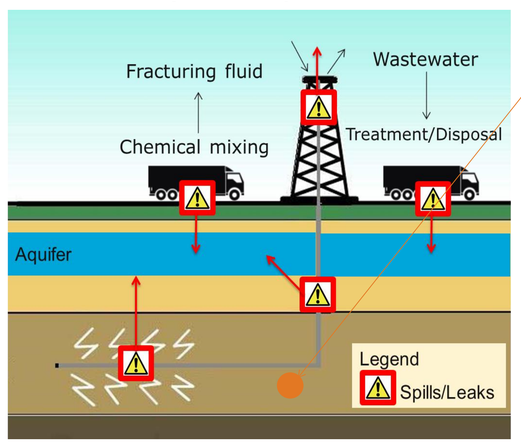
socopse.se (2018)

➢ Surface conditions

Pressure	Temperature
1 bar	25 ^{0}C

Models for oil and gas activities need to consider ...

➢ More complex exposure routes



➢ Downhole conditions (≈4 km)

Pressure	Temperature
450 bar	100 ^{0}C

Scientific approach (focus on deep subsoil)

⇒ **Dissolution**

⇒ **Adsorbance**

⇒ **Degradation /Transformation**

High P and T vs **Atmospheric Conditions**

1. **Chemical analysis** of <u>liquid</u> and <u>solid</u> phase
2. **Bioassay assessment** of <u>liquid</u> phase

Materials & Methods

Experimental conditions

	Test Samples				Controls (per Test)		
	Test 1 (T)	Test 2 (P)	Test 3 (P+T)	Test 4 (atm)	Ctrl 1	Ctrl 2	Ctrl 3
T (◦C)	100	25	100	25	/	/	/
P(bar)	1	450	450	1	/	/	/
Flowback (mL)	7	7	7	7	H_2O	8	H_2O
Shale (g/mL)	0.125	0.125	0.125	0.125	0.125	0	0

Sample treatment

1. Filtration (0.2 µm)
2. Analysis

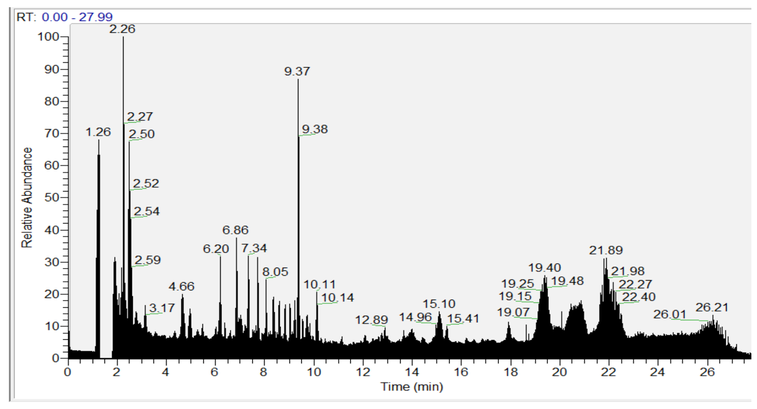
1. Vacuum filtration
2. Accelerated Solvent Extraction
3. Evaporation/redillution in H_2O
4. Filtration (0.2 µm)
5. Analysis

Analysis

1. LC-HRMS LC/linear ion trap (LTQ) Orbitrap High Resolution Mass Spectrometry

Non -target screening using a **suspect list**[4] including...

- **Fracturing additives**[5] and
- **Subsurface contaminants**[3,6,7,8,9,...]



(Preliminary) Non-target result for original flowback sample (m/z 80-1300)

2. AMES Fluctuation Test - Genotoxicity

- TA98 +/- S9*: frame shift mutations
- TA100 +/- S9*: base-pair substitutions

* with/out metabolic activation (liver enzymes)

Results are expected first quarter of 2019

References

1. **Kahrilas** GA, Blotevogel J, Stewart PS, Borch T (2014). Environ Sci Technol 49:16-32 2. **Kahrilas** GA, Blotevogel J, Corrin ER, Borch T (2016. Environ Sci Technol 50:11414-11423 3. **Abualfaraj,** N., Gurian, P.L., & Olson, M.S. (2014). *Environmental Engineering Science*, *31*(9), 514-524.; 4. **Faber,** A.H., Annevelink MPJA, Gilissen HK, Schot, P.P., van Rijswieck M., de Voogt, W.P., van Wezel, A.P. (2018).; 5. **Fracfocus 2016**: *https://fracfocus.org/*; 6. **Orem**, W., Tatu, C., Varonka, M., Lerch, H., Bates, A., Engle, M., ... & McIntosh, J. (2014). *International Journal of Coal Geology*, *126*, 20-31.; 7. **Olsson**, O., Weichgrebe, D., & Rosenwinkel, K.H. (2013). *Environmental earth sciences*, *70*(8), 3895-3906.; 8. **Tang**, J.Y., Taulis, M., Edebeli, J., Leusch, F.D., Jagals, P., Jackson, G.P., & Escher, B.I. (2015). *Environmental Chemistry*, *12*(3), 267-285.; 9. **Thacker,** J.B., Carlton, D.D., Hildenbrand, Z.L., Kadjo, A.F., & Schug, K.A. (2015). *Water*, *7*(4), 1568-1579.

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Research topic: Chemical risks of hydraulic fracturing for water systems in the Netherlands (2015-2019).
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