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# Energy production and chemical emissions

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# Chemicals; we use them all, day by day







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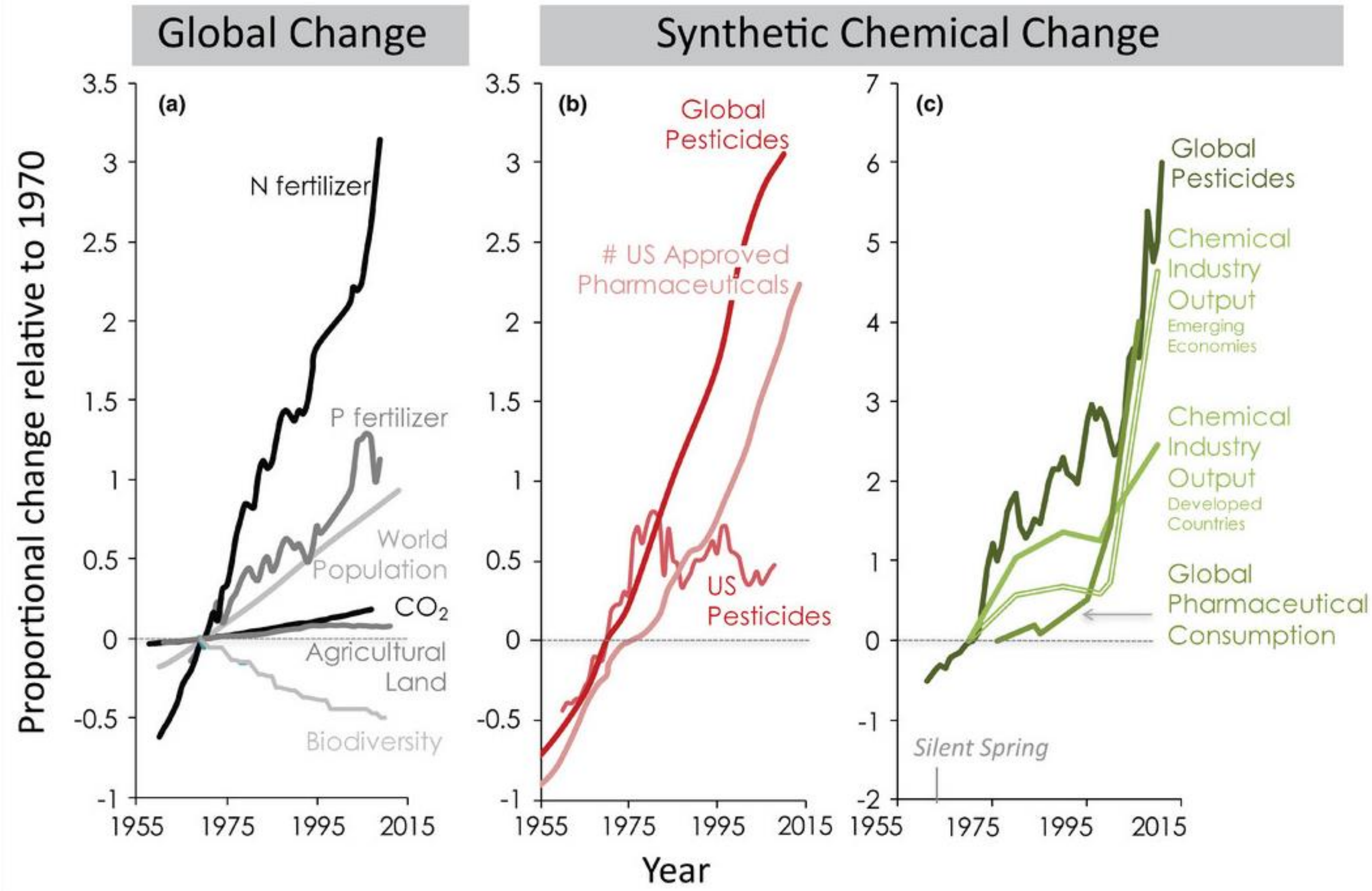
# More and more…growth in numbers and volumes of synthetic chemicals used outpace other factors of global change

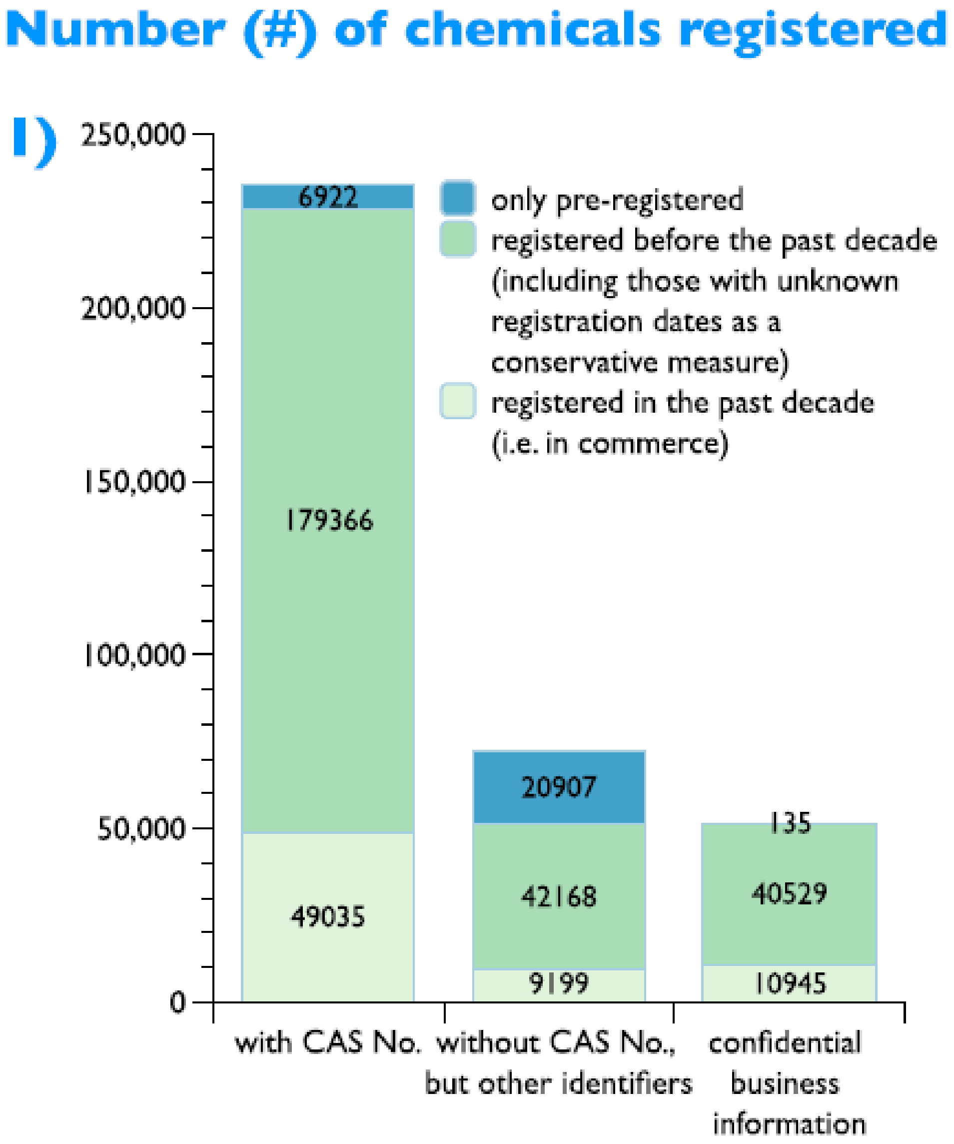



Bernhardt et al 2017 Front Ecol Environ

# Global Understanding of Chemical Pollution

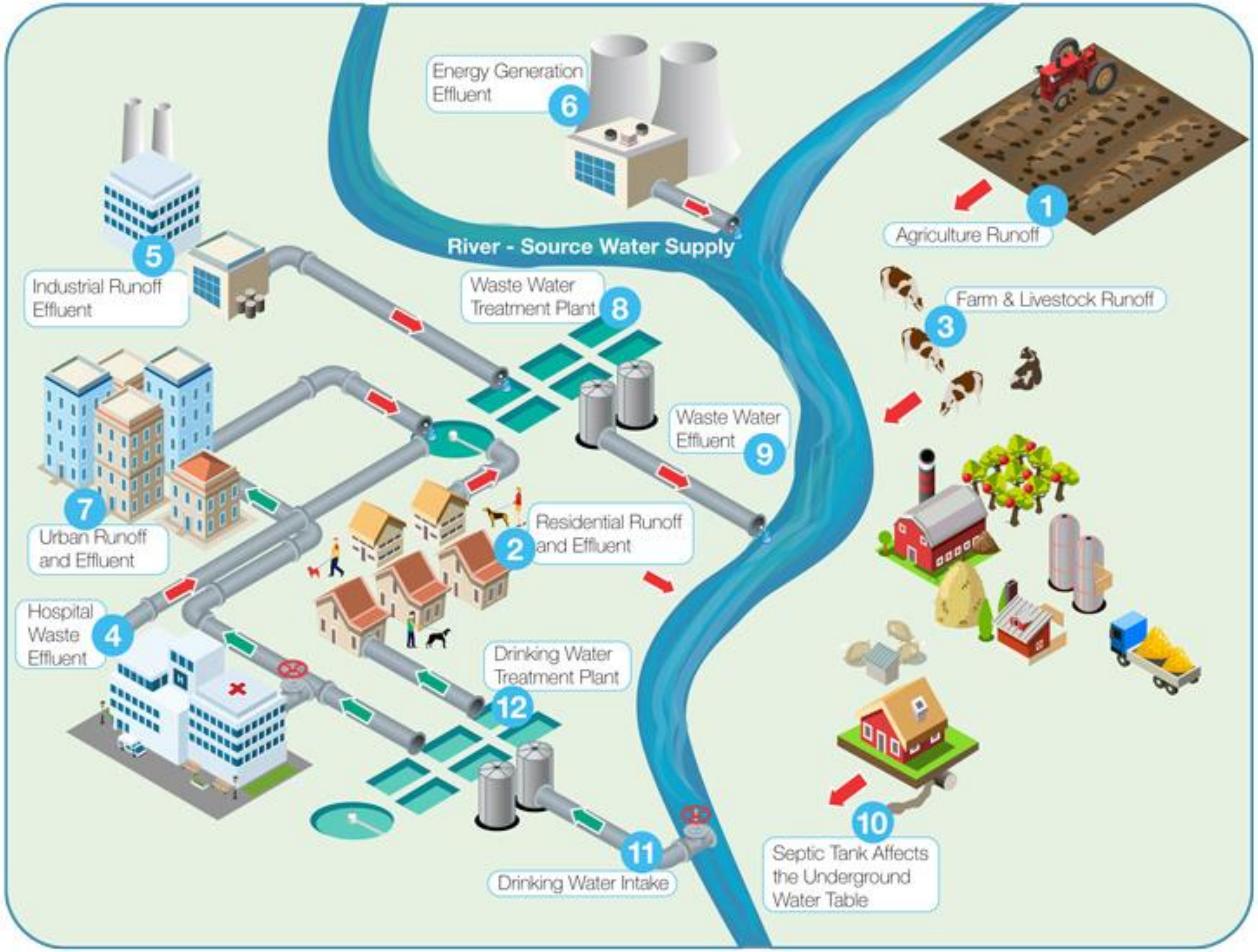
Over 350 000 chemicals and mixtures registered for production and use worldwide

Identities of many chemicals publicly unknown, claimed as confidential (over 50 000) or ambiguously described (up to 70 000)




Wang et al 2020

# Emission sources of chemicals

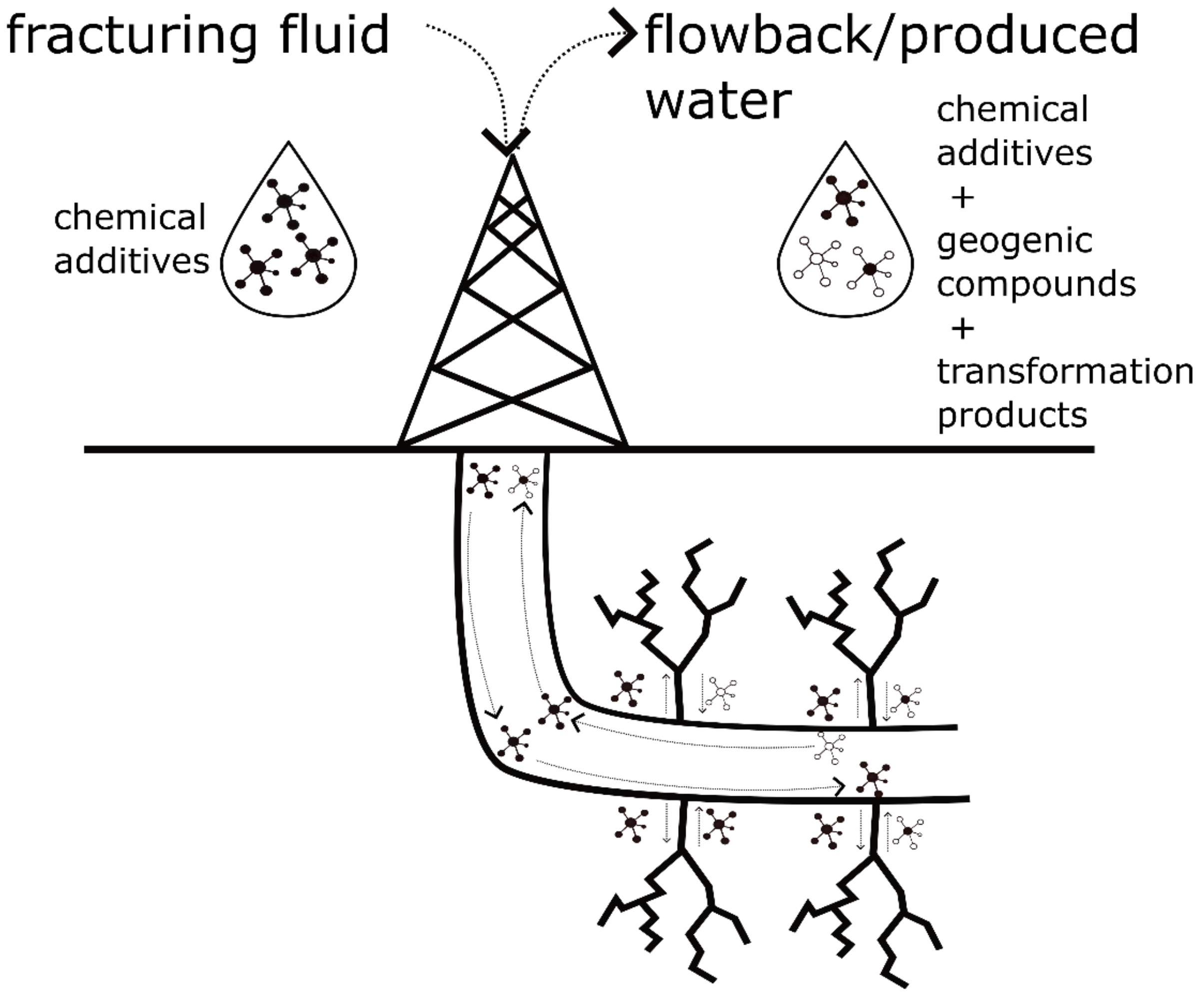


# Dec 2019: EU Green Deal with Zero pollution ambition

# Chemicals Strategy for Sustainability (CSS, October ‘20)

- First regional framework addressing chemical pollution in a holistic manner
- Covers complete life-cycle of a chemical, including design and remediation options

# Chemical pressures related to hydraulic fracturing



## What are the chemical risks of unconventional oil and gas (UO&G) activities in relation to water resources?

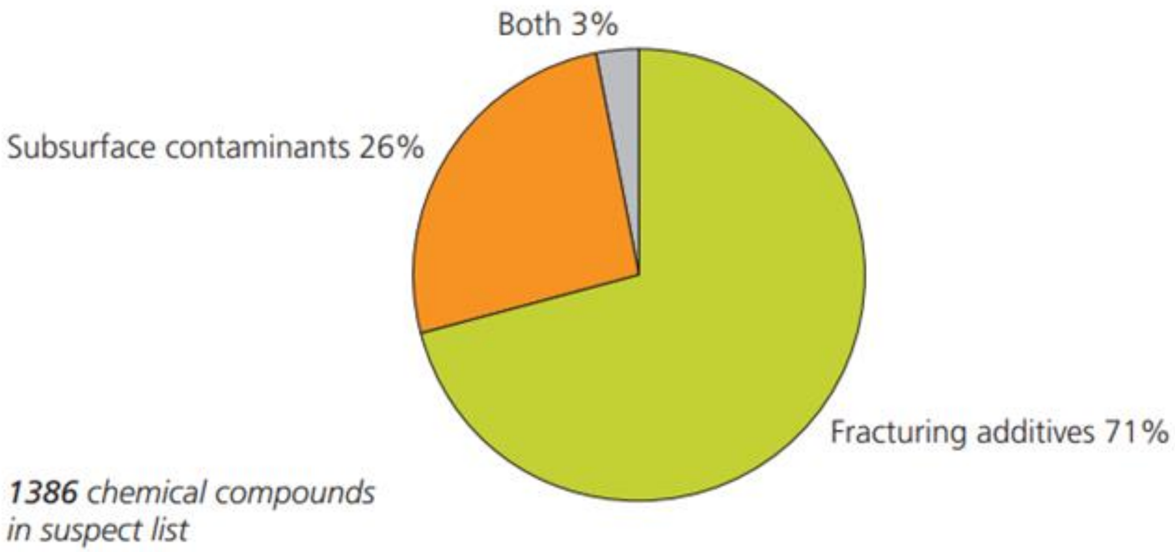
### 1. How should chemical risk assessment for UO&G activities be carried out?

| Research question | Approach | Chapter |
|---|---|---|
| **1.1** How does chemical risk assessment need to be adapted for UO&G activities? | **1.1** Literature review on what is known on UO&G related risk assessment. | Chapter 2 |
| **1.2** What chemicals are used in UO&G activities in the European context and how harmful are they? | **1.2** Chemical and bioassay assessment of UO&G related samples from a Dutch tight gas hydraulic fracturing site. | Chapter 3 |
| **1.3** Can current environmental fate models be used to evaluate environmental fate of UO&G related chemicals? | **1.3** Study on the effects of high pressure and temperature on chemical fate of UO&G related chemicals. | Chapter 4 |

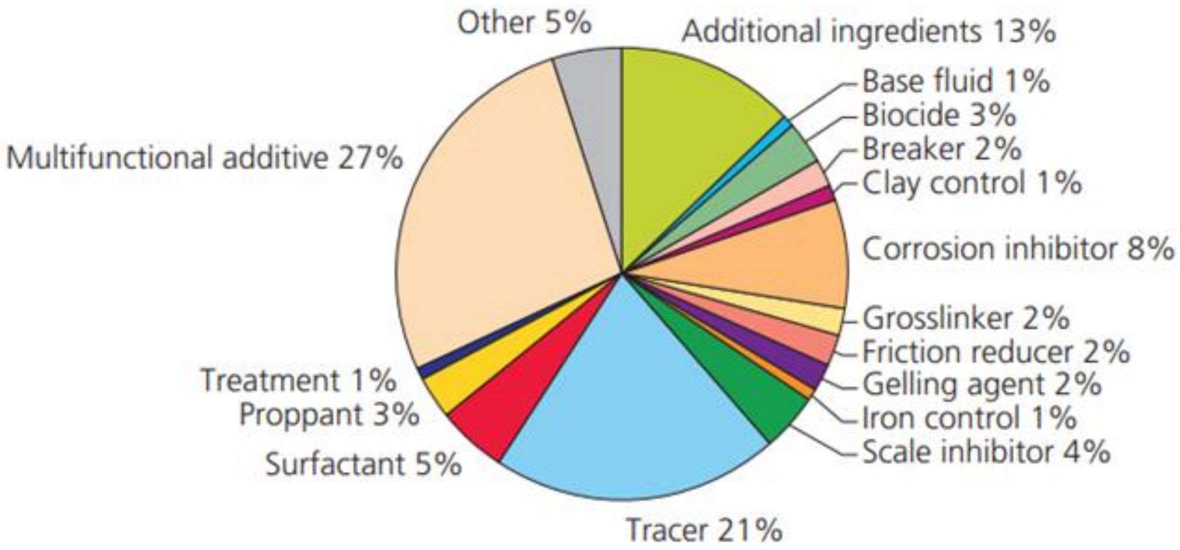
### 2. How can chemical risks related to UO&G activities be mitigated?

| Research question | Approach | Chapter |
|---|---|---|
| **2.1** What are the best wastewater treatment practices for UO&G related waters? | **2.1** Investigation of of removal efficiencies of DOC by ozonation, sorption to granular activated carbon and aerobic degradation. | Chapter 5 |
| **2.2** Can the use of green chemicals in fracturing fluid mitigate potential risks of UO&G activities on the water system? | **2.2** Chemical and bioassay assessment of fracturing fluids marketed as conventional and green and the comparisons thereof. | Chapter 6 |

## Composition of hydraulic fracturing related suspect list




## Overview of fracturing fluid additive purposes



# Spill/leak probabilities and spill volume estimates based on US publicly available databases (2010-2015)

| Contamination pathway | Fluid released | Frequency (%/well/year) | Average spill volume ($m^3$) |
|---|---|---|---|
| Surface spill | Drilling mud | 0.005–2.8 | 294 ± 185.7 |
| | Fracturing fluid | 0.02–0.1 | 24 ± 28 |
| | Produced water | 0.02–4.4 | 12 ± 29.1 |
| | Oil-based fluid | 0.05–2.8 | 1 ± 6 |
| Blowout | Drilling mud | 0.004 | 185 ± 256 |
| | Produced water | 0.0002–0.01 | 3,206 ± 7,843 |
| | Oil-based fluid | 0.002–0.01 | 49 ± 243 |
| Leaking connectivity | Drilling mud | 0.01 | 43 ± 50 |
| | Produced water | 0.2 | 12 ± 26 |
| | Oil-based fluid | 0.1 | 6 ± 14 |
| Corroding well casing | Oil-based fluid | 0.05–0.7 | 9 ± 20 |
| | Drilling mud | 0.001–0.004 | 4 ± 4 |
| | Produced water | 0.002–1 | 11 ± 41 |
| Insufficient cementing | Not specified | 1.6 | Not specified |

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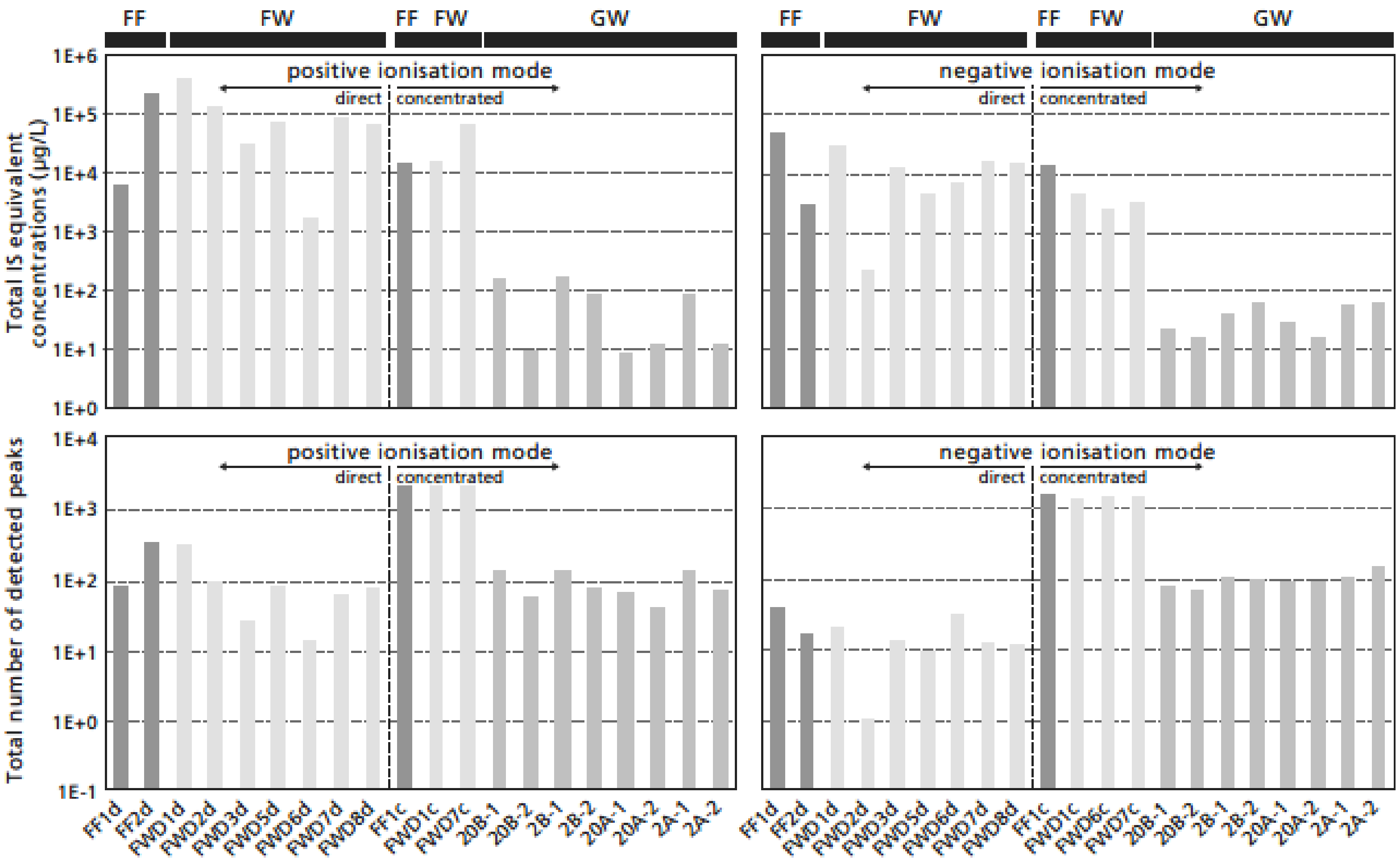
# Chemical and bioassay assessment of waters related to hydraulic fracturing at a tight gas production site



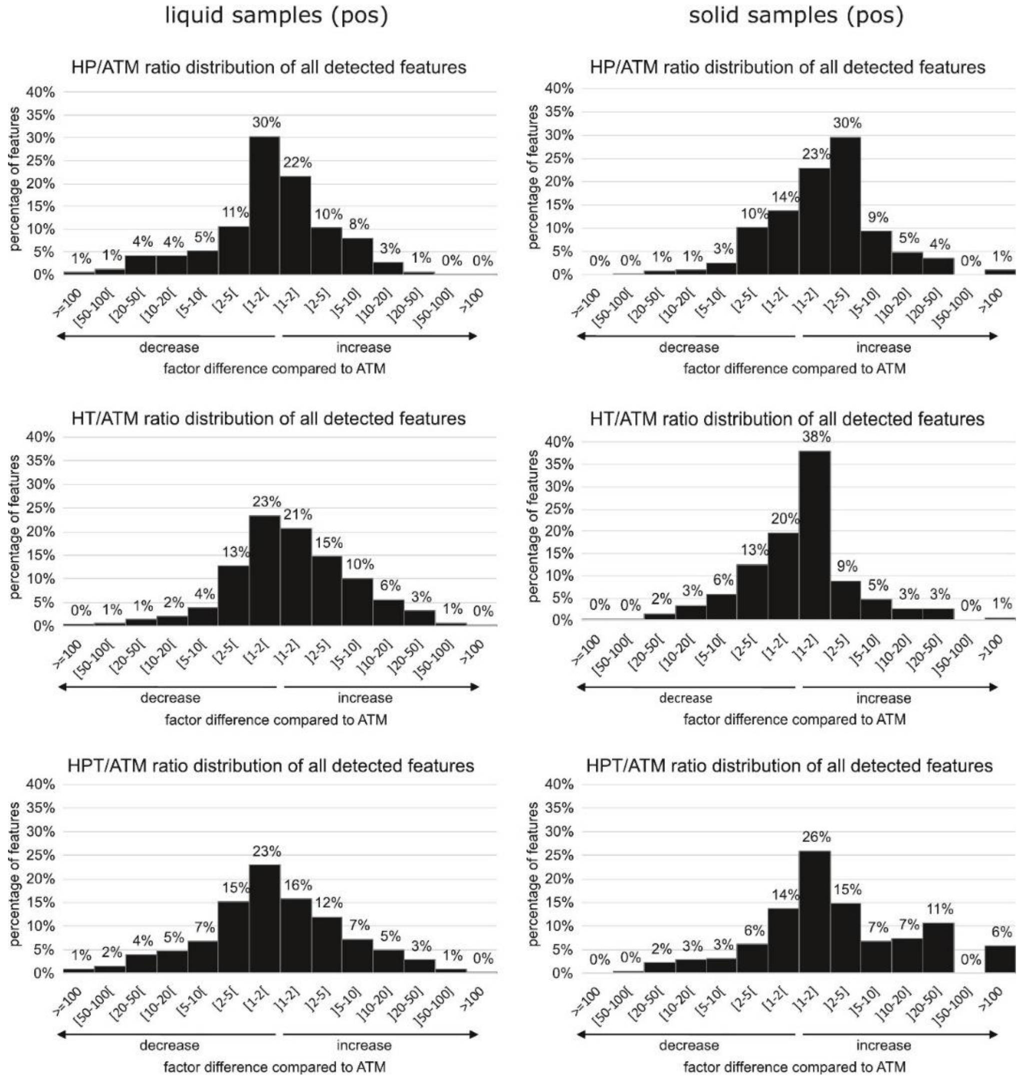

High number of peaks in FF and FW samples.

No clear differences in chemical composition were shown in the groundwater samples before and after hydraulic fracturing.

Preliminary environmental fate data of the tentatively identified chemicals points towards persistence in water.

Clear genotoxic and oxidative stress responses were found in the fracturing fluid and flowback samples.

# Effects of high pressure (450 bar) and temperature conditions (100 C) on the chemical fate of flowback water related chemicals

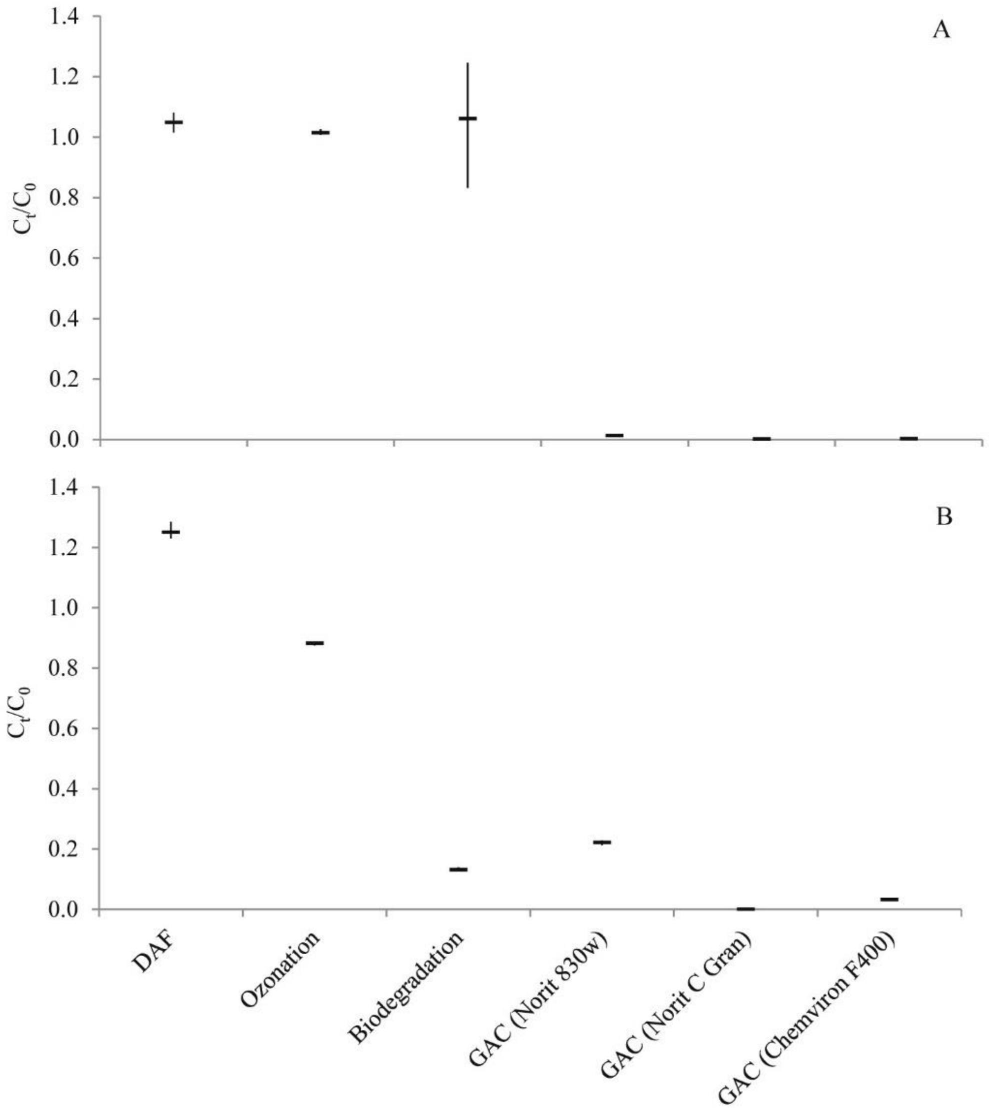



Environmental fate models based on surface conditions may be used for an approximation of chemical fate under downhole conditions by applying an additional factor of five to account for these uncertainties.

# Removal of organic compounds from flowback water

Combination of aerobic degradation with adsorption to activated carbon is proposed to be implemented between pre-treatment (dissolved air floatation) and desalination (thermal or membrane desalination) steps

The fraction of the organic compounds detected in positive (A) and negative (B) ionisation mode (Ct/C0), which was left after DAF, ozonation, biodegradation and adsorption to GA



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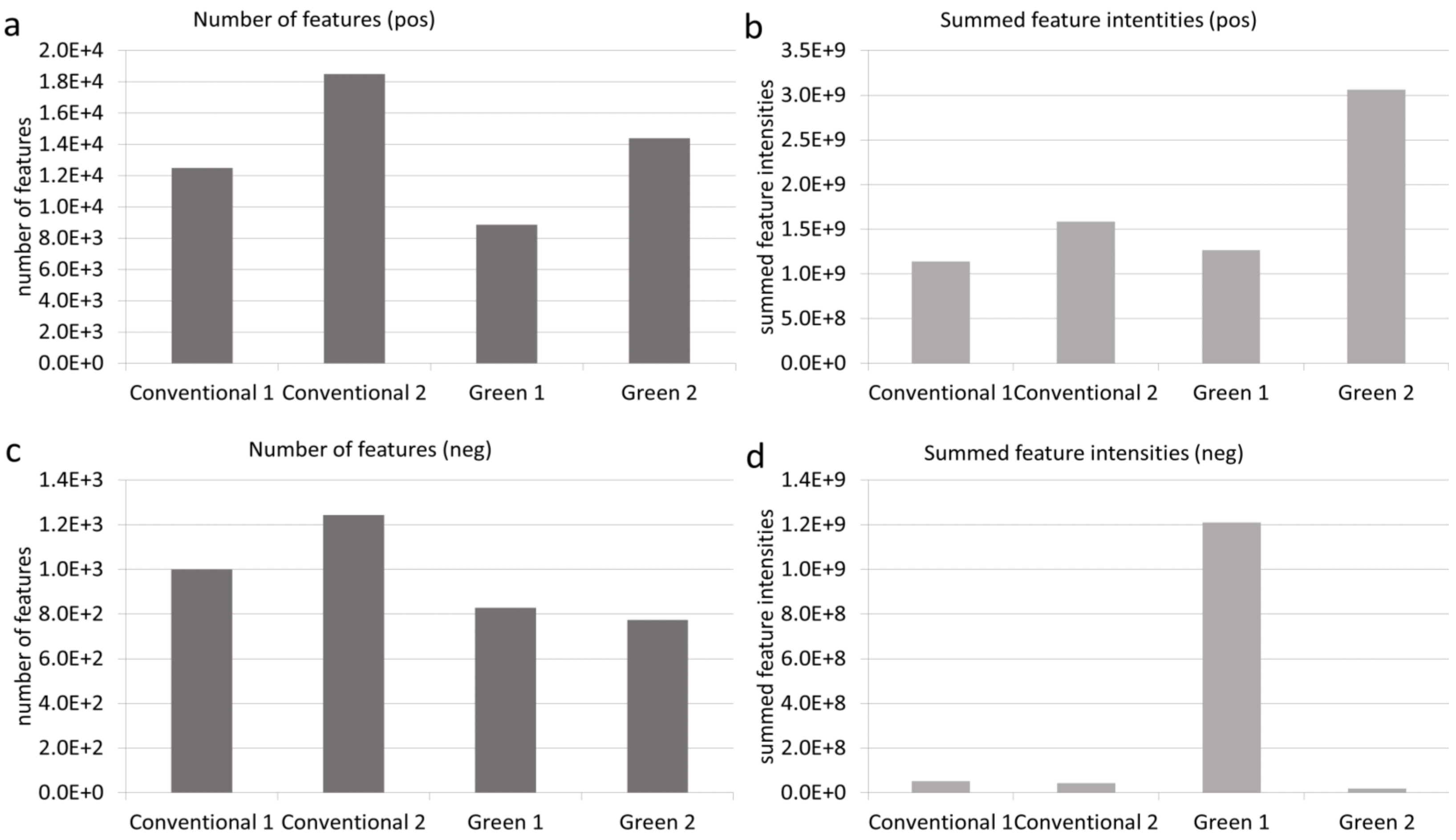
# Comparing conventional and green fracturing fluids by chemical characterisation and effect-based screening



No clear indication that the selected green fluids contain chemicals present at lower concentrations than the selected conventional fluids.

Ames fluctuation test results indicate that the green fluids have a similar genotoxic potential than the conventional fluids. Results of the CALUX reporter gene assays add to the evidence that there is no clear difference between the green and conventional fluids.

The results do not support the claim that currently available and tested green-labelled fracturing fluids are environmentally more friendly alternatives to conventional fracturing fluids.

| Samples | Chemical analyses results | | | | Bioassay test results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Positive ionisation | | Negative ionisation | | Ames test[d] | | | | CALUX test | | | | | |
| | # feat.[b] | Σ feat. int.[c] | # feat. | Σ feat. int. | TA98 -S9 | TA98 + S9 | TA100 -S9 | TA100 + S9 | anti-AR | ERα | nrf2 | PAH | p53 +/-S9 | cytotox |
| Tap water 1 | 1.06E+02 | 8.92E+05 | 3.40E+01 | 6.92E+05 | – | – | – | – | – | – | – | – | – | – |
| Tap water 2 | 8.10E+01 | 3.96E+05 | 3.00E+01 | 1.75E+05 | – | – | – | – | – | – | – | – | – | – |
| Conv. 1 (WAF[a]) | 1.65E+04 | 1.29E+09 | 1.24E+03 | 5.65E+07 | no data | + 1:100 | – | – | + | (−) | (−) | (−) | (−) | + |
| Conv. 2 (WAF) | 2.22E+04 | 1.61E+09 | 1.38E+03 | 4.47E+07 | no data | no data | – | + 1:1 | – | – | – | – | – | – |
| Conv. 2 (suspension) | / | / | / | / | – | + 1:1 | – | (+) 1:1 | – | – | – | – | – | – |
| Green 1 (WAF) | 1.10E+04 | 1.32E+09 | 1.02E+03 | 1.27E+09 | – | – | + 1:30 | (+) 1:1 | – | – | – | – | – | – |
| Green 2 (WAF) | 1.72E+04 | 3.09E+09 | 8.76E+02 | 1.99E+07 | – | – | – | + 1:10 | – | – | – | – | – | – |
| Green 2 (suspension) | / | / | / | / | (+) 1:1 | + 1:1 | + 1:1 | (+) 1:1 | – | – | – | – | – | – |

# References and acknowlegdements

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