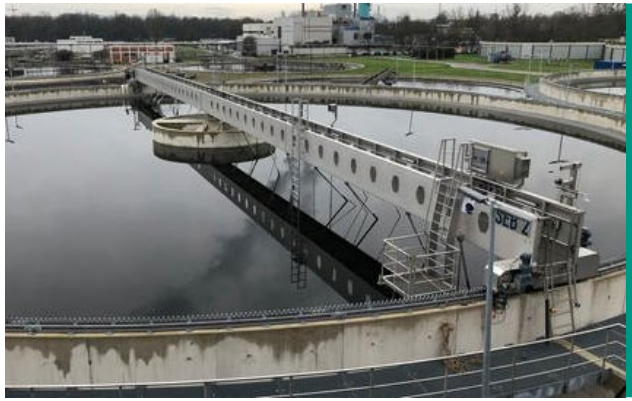
Karlsruhe Institute of Technology

NEXTGEN roadfuels

Hydrothermal Liquefaction of Sewage Sludge

Fractional Extraction and Characterization of Nitrogen-Compounds from the Biocrude matrix



HTL

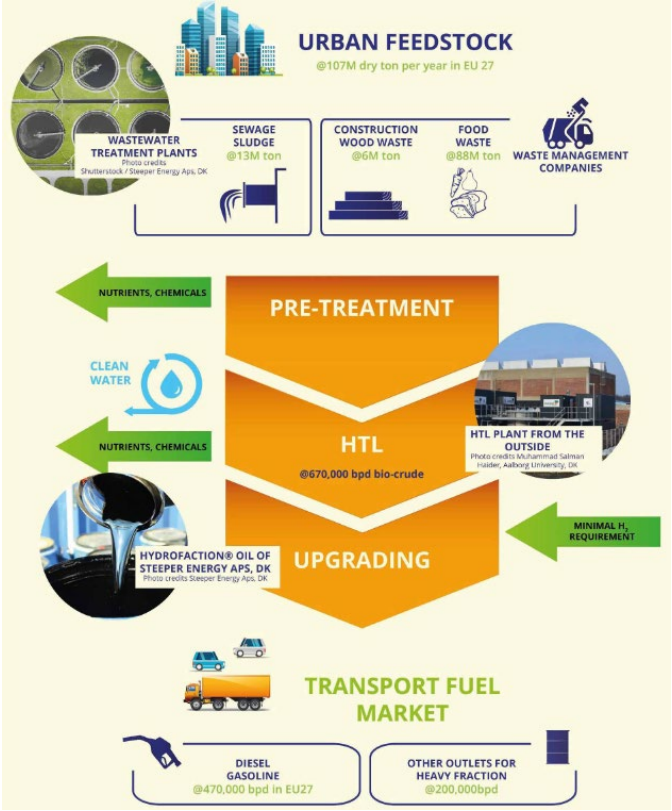
[SWR aktuell - 2022]

[Steeper Energy – 2018]

The NextGenRoadFuels (NGRF) Project
Converting urban Waste into drop in fuel

NGRF is a Horizon 2020 project to develop a competitive European technology platform for a sustainable liquid fuel production.

NGRF aim to prove the HTL pathway as an efficient route to produce high-volume, cost-competitive, drop-in synthetic gasoline and diesel fuels, as well as other hydrocarbon compounds from urban waste residues.

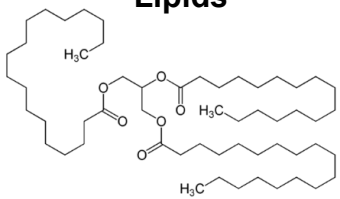


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818413

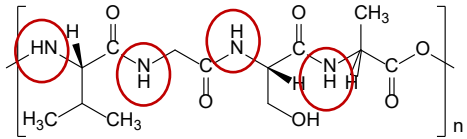
Hydrothermal liquefaction
From Polymers to Monomers

Biogenic polymers

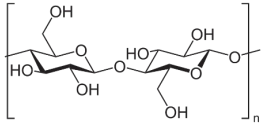
Lipids



Proteins



Polysaccharides



Use properties of pressurized **water** at **elevated temperatures.**

1. **Depolymerisation**
2. **Recombination**
3. **Condensation**

Biocrude product

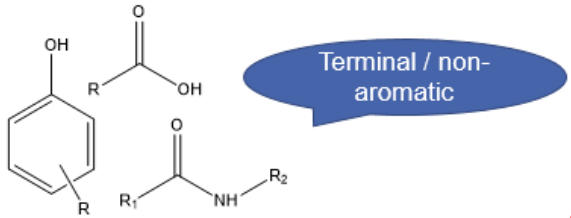
>10 000 of different compounds

Wide range of N-compounds

Hydrothermal liquefaction
Heteroatoms in compounds

Biocrude product – Elemental composition

	Petroleum[2]	HTL Biocrude[3]
Carbon (wt.%)	83 – 87	76.0
Hydrogen (wt.%)	10 – 14	11.0
Nitrogen (wt.%)	0.1 – 2	3.8
Sulfur (wt.%)	0.05−6	1.0
Oxygen (wt.%)	0.05 – 1.5	8.2



Refining:
- Distillation
- HDS

Upgrading:
- HDO
- HDN

H2

Blending

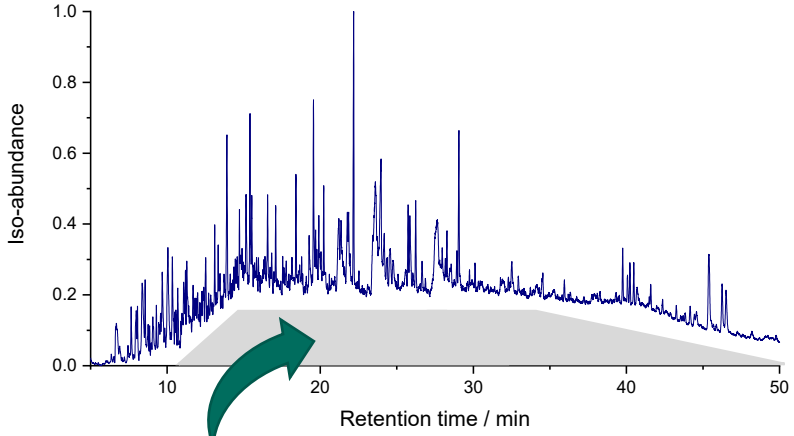
[2][J. Speight "The Chemistry and Technology of Petroleum" 2006]

[3][Sewage sludge HTL - Campaign from 2019]

Biocrude Characterization
Complex chemical composition

	HTL Biocrude[3]
Carbon (wt.%)	76.0
Hydrogen (wt.%)	11.0
Nitrogen (wt.%)	3.8
Sulfur (wt.%)	1.0
Oxygen (wt.%)	8.2

Analysis of chemical composition



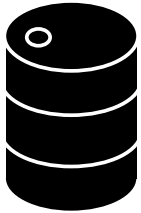
N?

- multi-heteroatom compounds
- Aliphatic ?
- Aromatic ?
  - Basic ?
  - Acidic ?

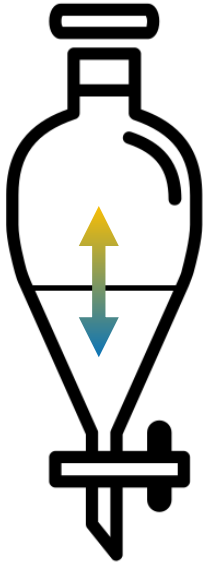
? Poor Resolution

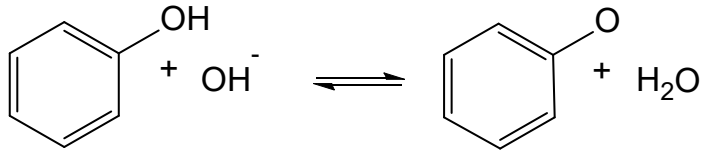
Simplify by Seperation
Solubility of polar heteroatom compounds

Non-polar (organic) solvent



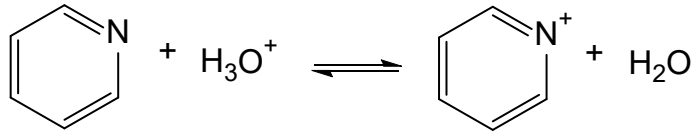
polar (aqueous) solvent





Phenol

Phenolate

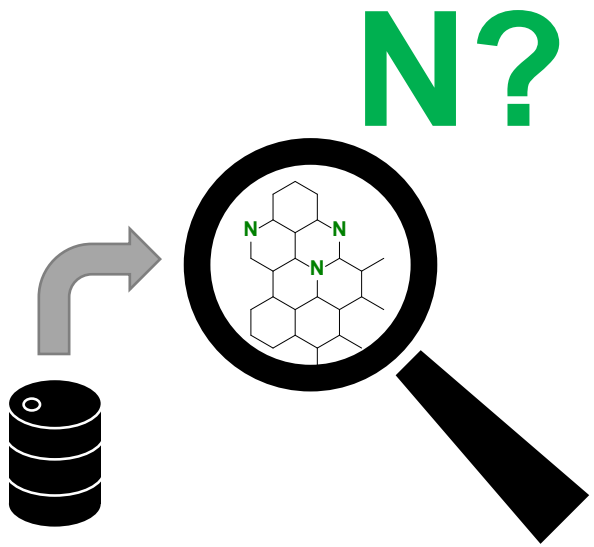


Pyridin

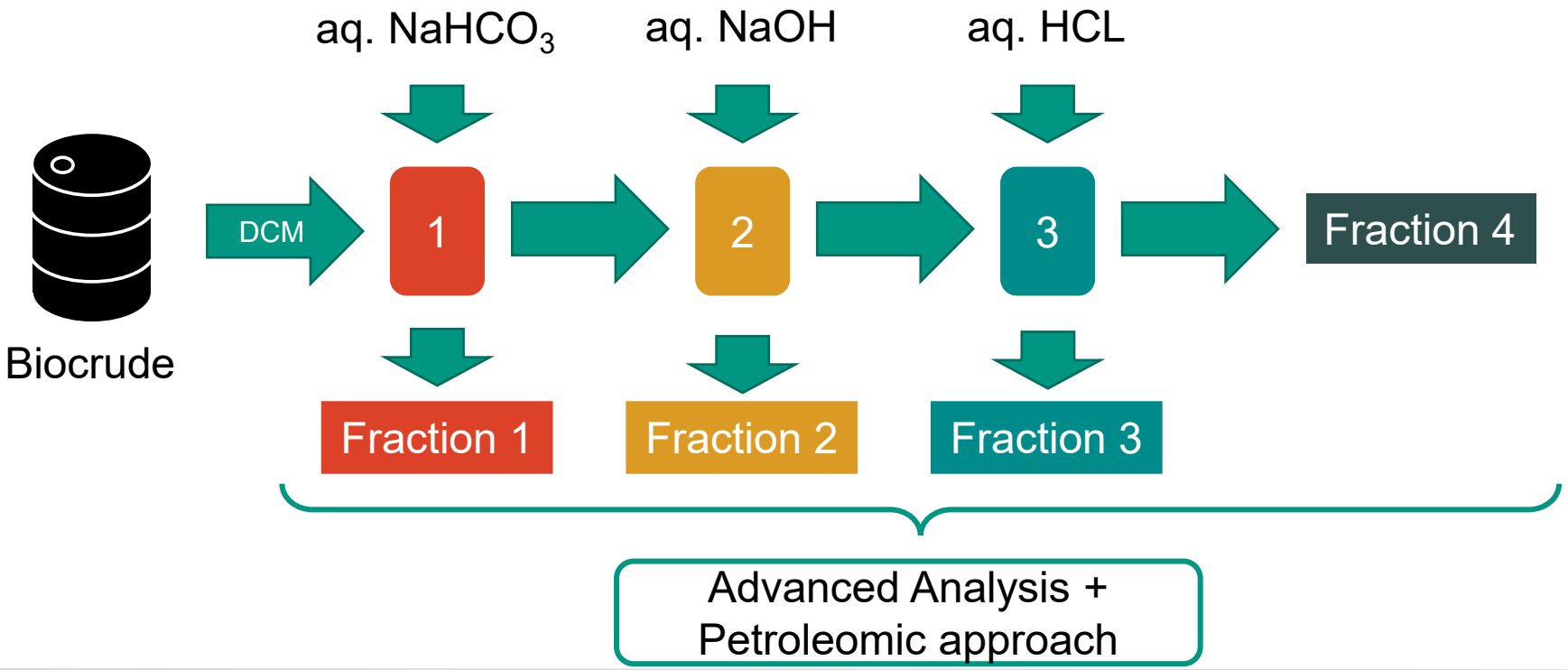
Pyridinium

Scope of this presentation

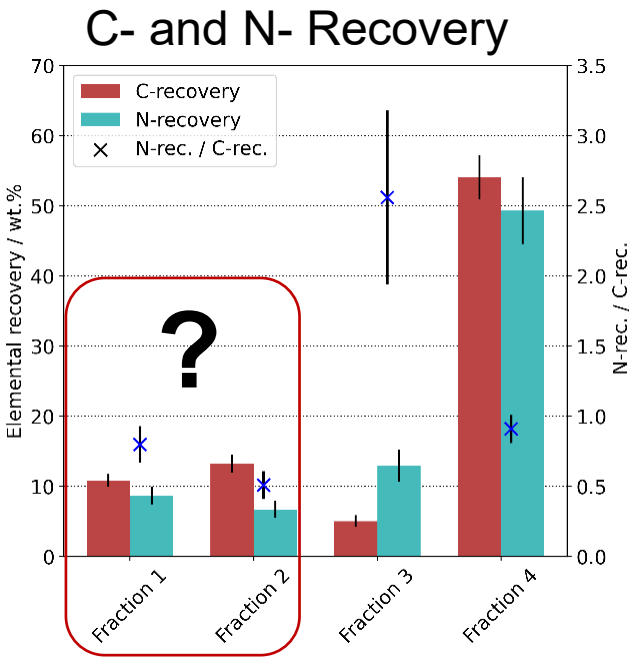
- Present a scheme for the separation of biocrude by polarity.
- Identify in which fraction carbon (C) and nitrogen (N) is recovered.
- Identify species of N-compounds in these fractions.
- Evaluate the aromaticity distribution of N-compounds over the fractions.



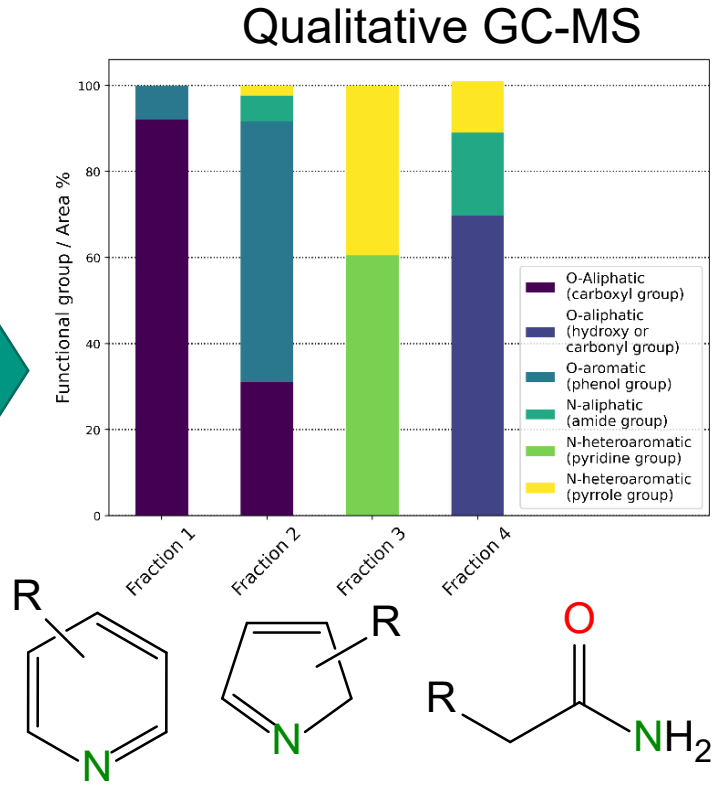
Applying the Seperation
Sequential extraction of polar compounds



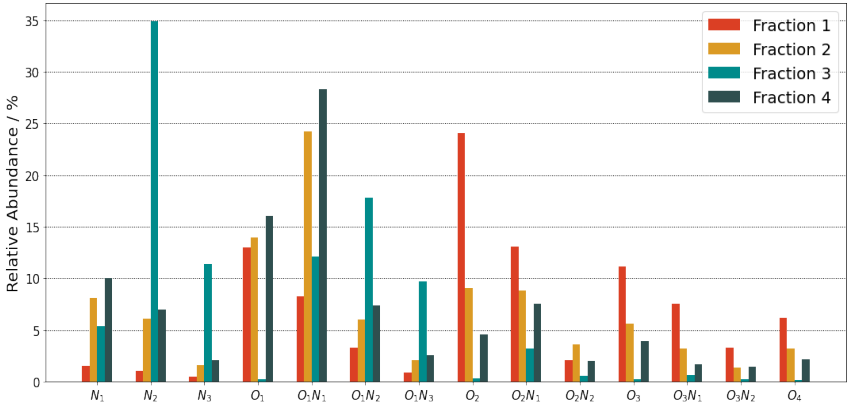
Solvent extraction and polar-aqueous solutions
C- and N-recovery into the extracted fractions



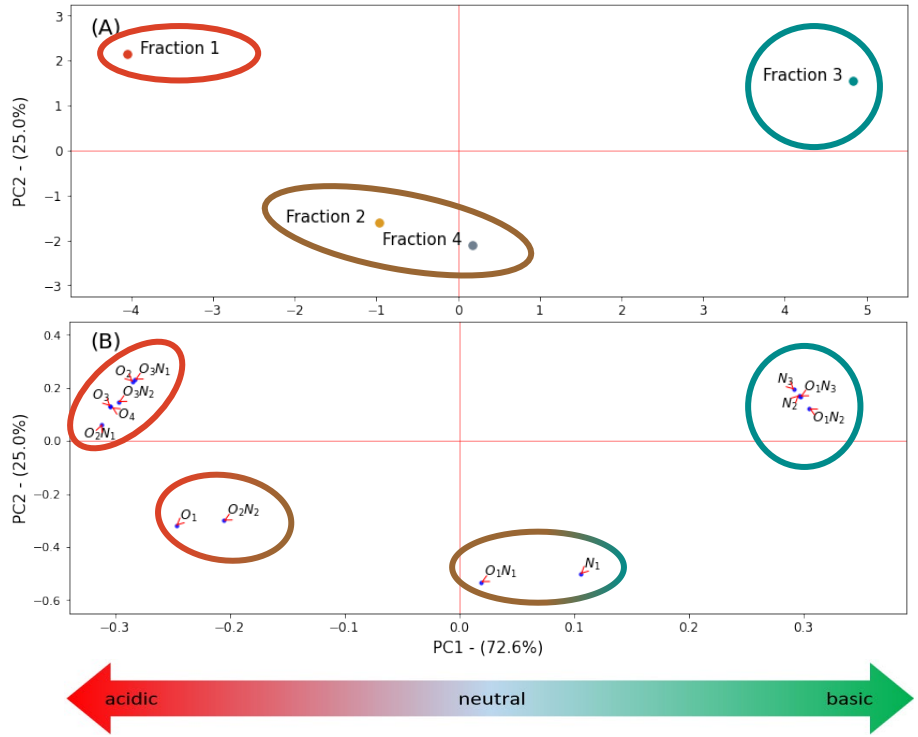
Analysis of chemical composition



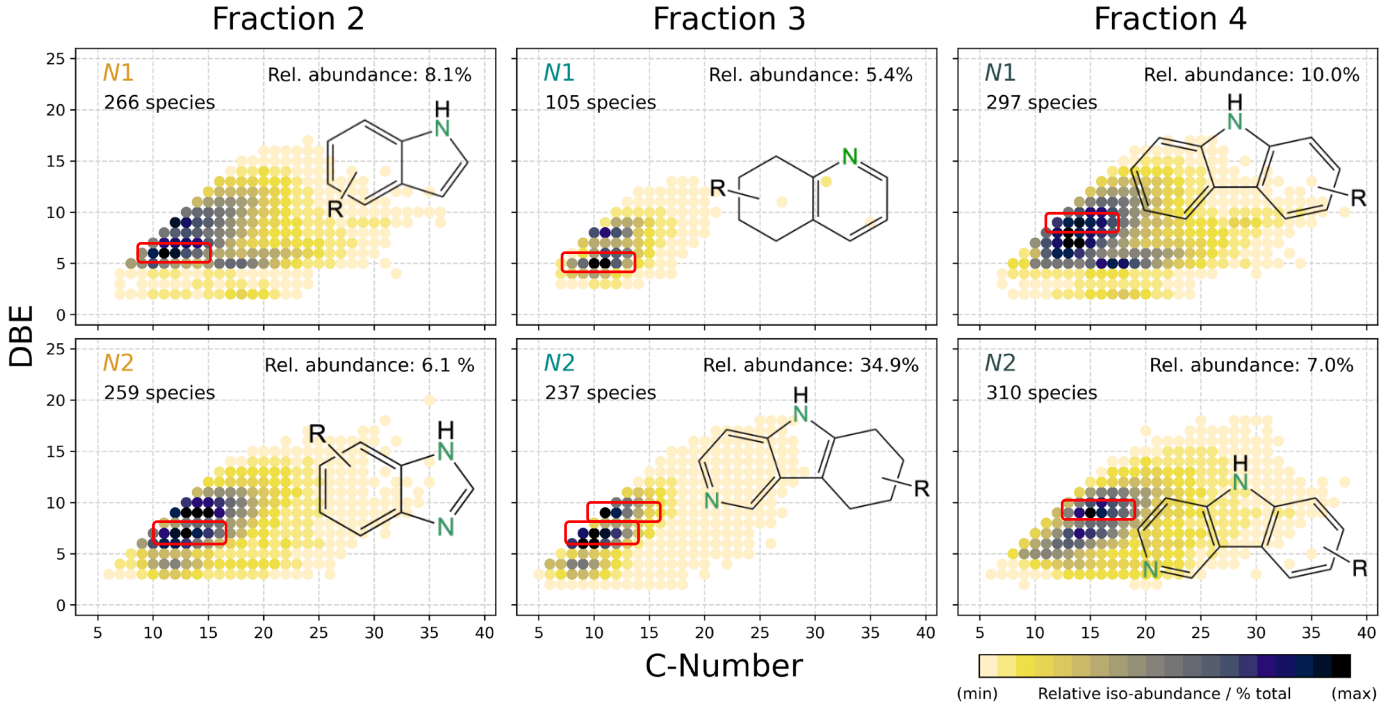
Solvent extraction and polar-aqueous solutions
Heteroatom classes and their distribution



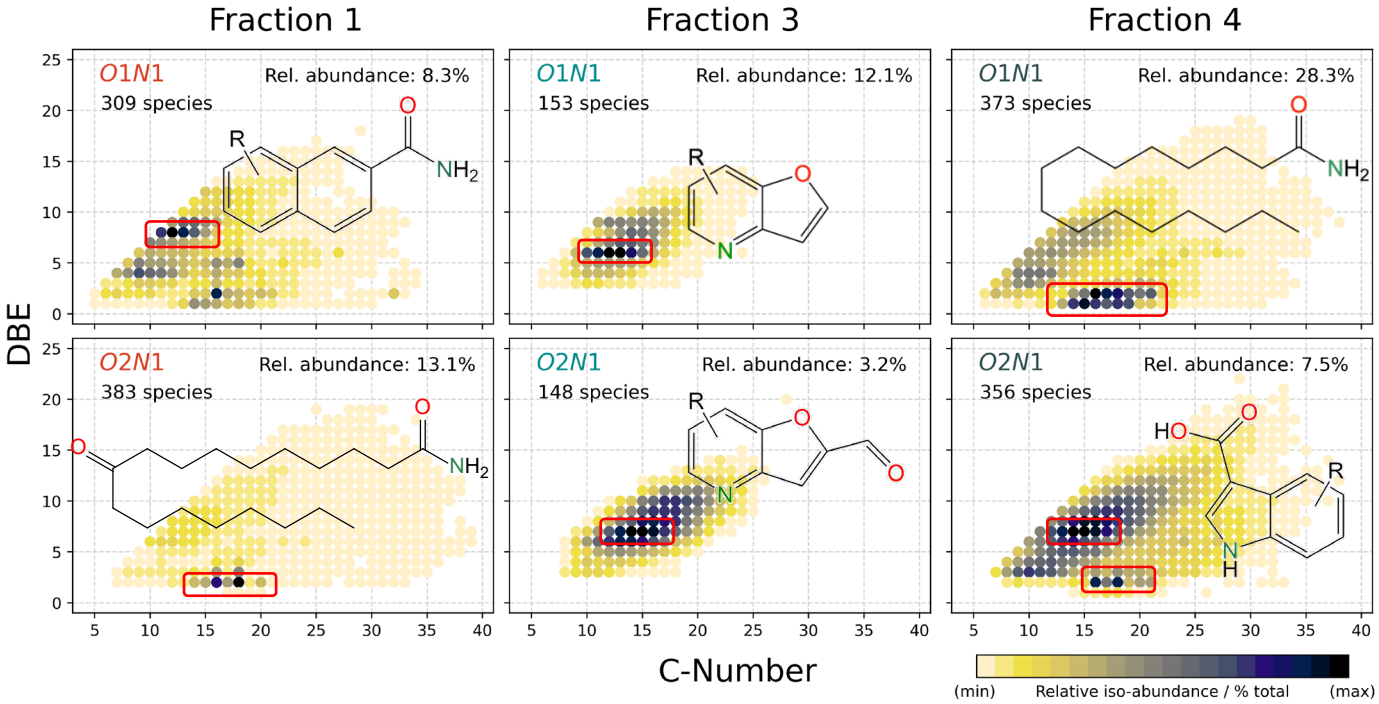
Explorative principal component analysis (PCA)



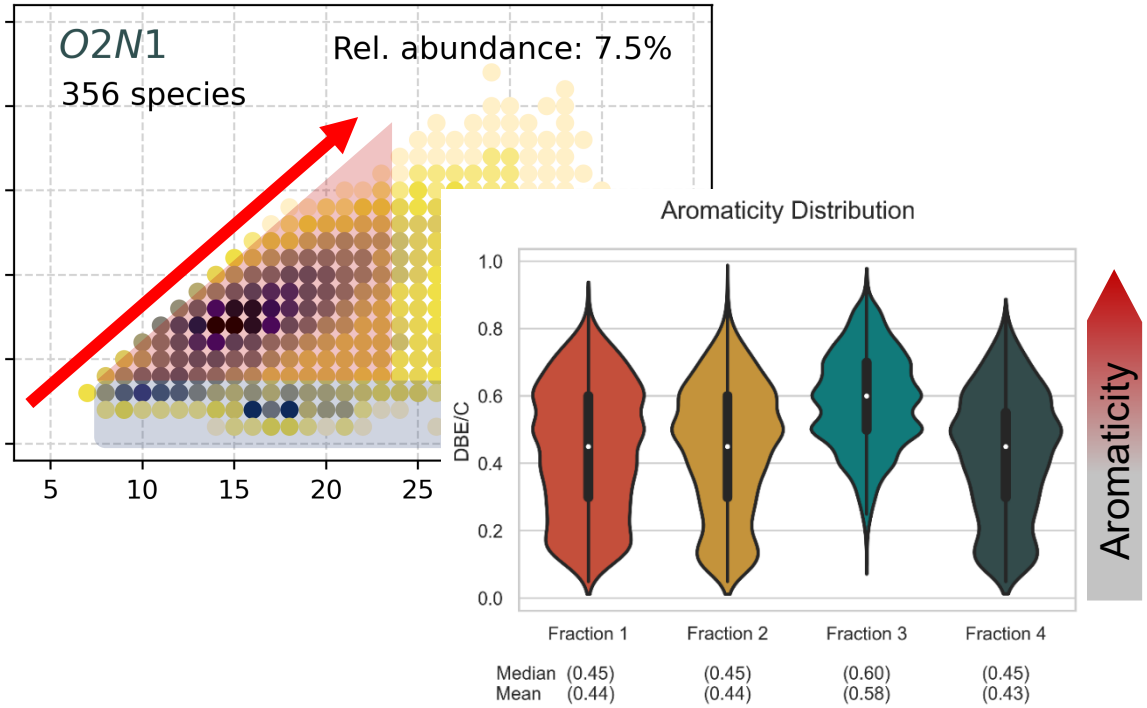
N-compounds in detail
N1 and N2 species



N-compounds in detail
O1N1 and O2N1 species



Aromaticity of N-compounds
Distribution over the fractions



- Definition of aromaticity over the DBE/C value
- High aromaticity found in Fraction 4
- Other Fractions show also aliphatic species

Conclusion and outlook

- N-compounds in biocrude can be separated based on their polarity.
- N-compounds show a strong basic character.
- Species identified in “acidic” Fractions are nearly always combined with oxygen heteroatoms.
- N-compounds with a basic character are nearly always identified as a heteroaromatic.
- Where to apply these results?

→ Downstream HTL: in product separation, LLE or adsorption of biocrude.

Thank You