Bruk av knust betong for å immobilisere uran fra svartskifer

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Background – concrete waste management and circular economy

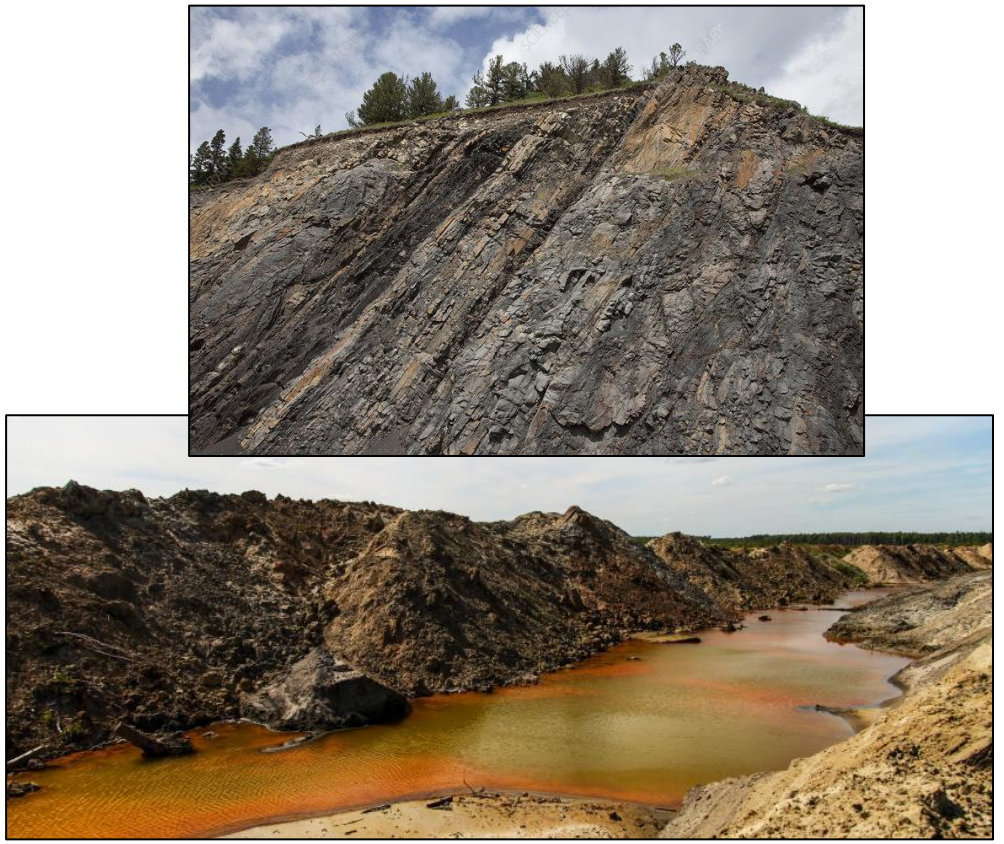
- Concrete is the most common building material in the world
- Norway (SSB, 2023):
  - 1.2 mill tons of concrete and brick waste
    - 80% goes to landfill (950 000 tons)
    - 4% for backfill (50 000 tons)
    - 6% recycling (70 000 tons)
    - 8% other (95 000 tons)

How can we recycle the concrete?

Acid rock drainage

- Black shale is a sedimentary rock
- Found in “Oslofeltet”
- Sedimentation of marine clay and organic material
- Sulphide will oxidate to sulphate and produce sulphur acid when black shale is exposed to air and water
- Low pH (<4)
- Causes metal leaching
  - Heavy metals, Uranium, Aluminium
- Acid production will accelerate the process

$$FeS_2 + {}^{15}/_{4}\,O_2 + {}^{7}/_{2}\,H_2O \rightarrow Fe(OH)_3 + 2SO_4^{2-} + 4H^+$$



https://www.energyinnovation.net.au/event/acid-mine-drainage-causes-consequences-and-remediation

Uranium

- Uranium (238U) naturally radioactive metal
- Rocks with ≥1 Bq/g defined as radioactive (U > 80 mg/kg)
- U4+ most common in reducing environment in the form of insoluble oxides
- U6+ most common in oxidizing conditions – very mobile
- Acid producing rock must be deposited at an approved landfill for radioactive waste

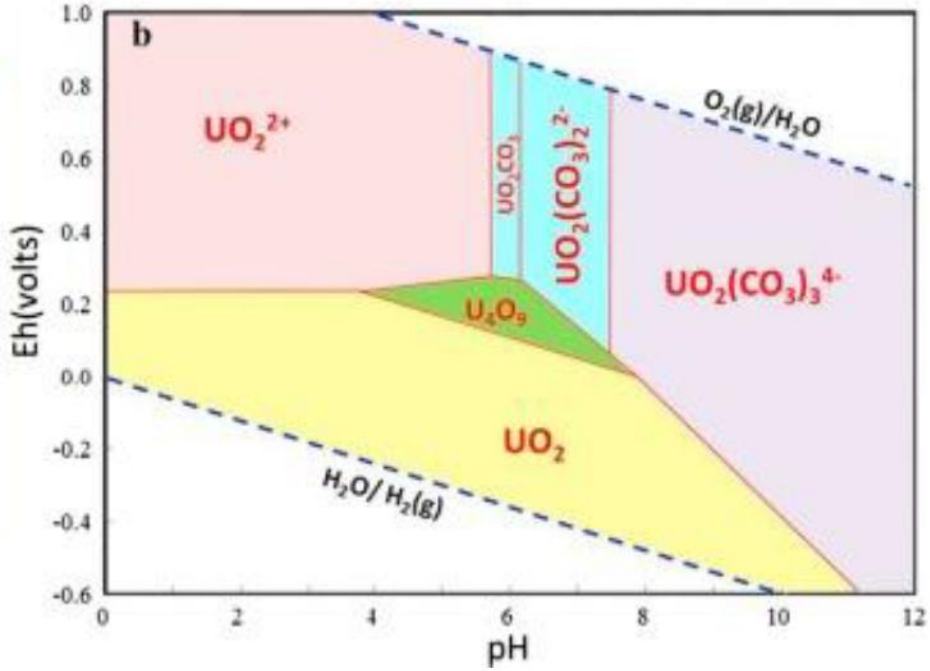
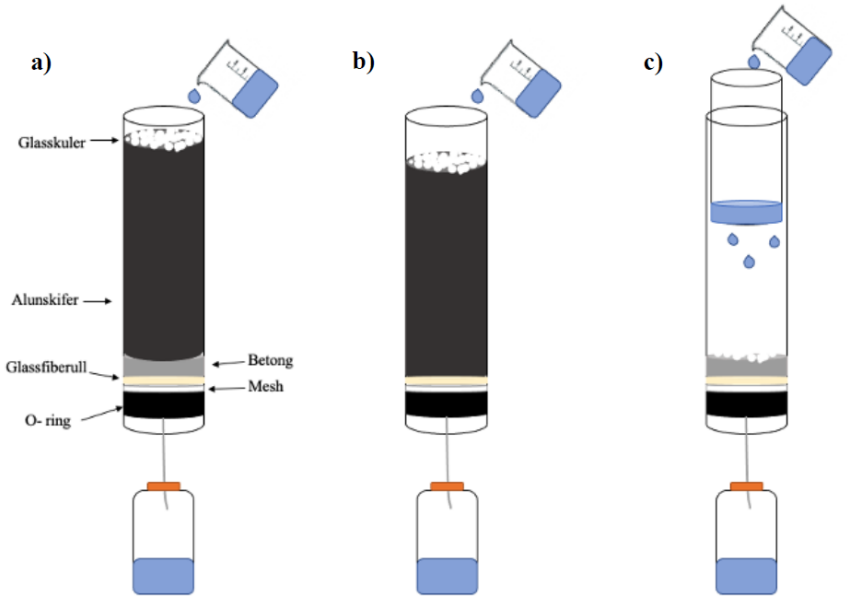


Figure: Xie, Y., Chena, C., Rena, X., Wangd, X., Wange, H. & Wang, X. (2019). Emerging natural and tailored materials for uranium-contaminated water treatment and environmental remediation.

Laboratory and field tests



Ugstad, 2023

pH

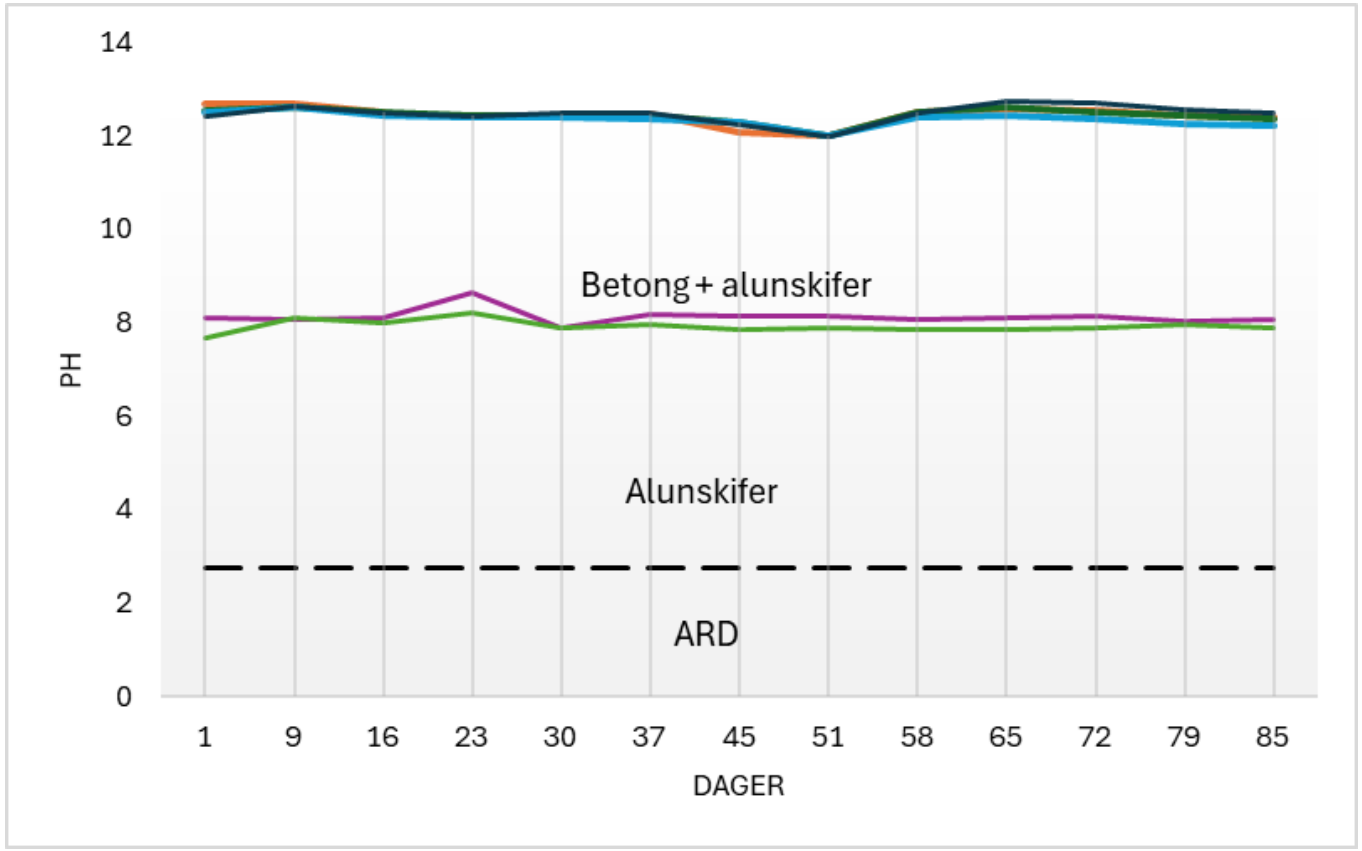
Betong alene ~ 12.5

Alunskifer alene ~ 8

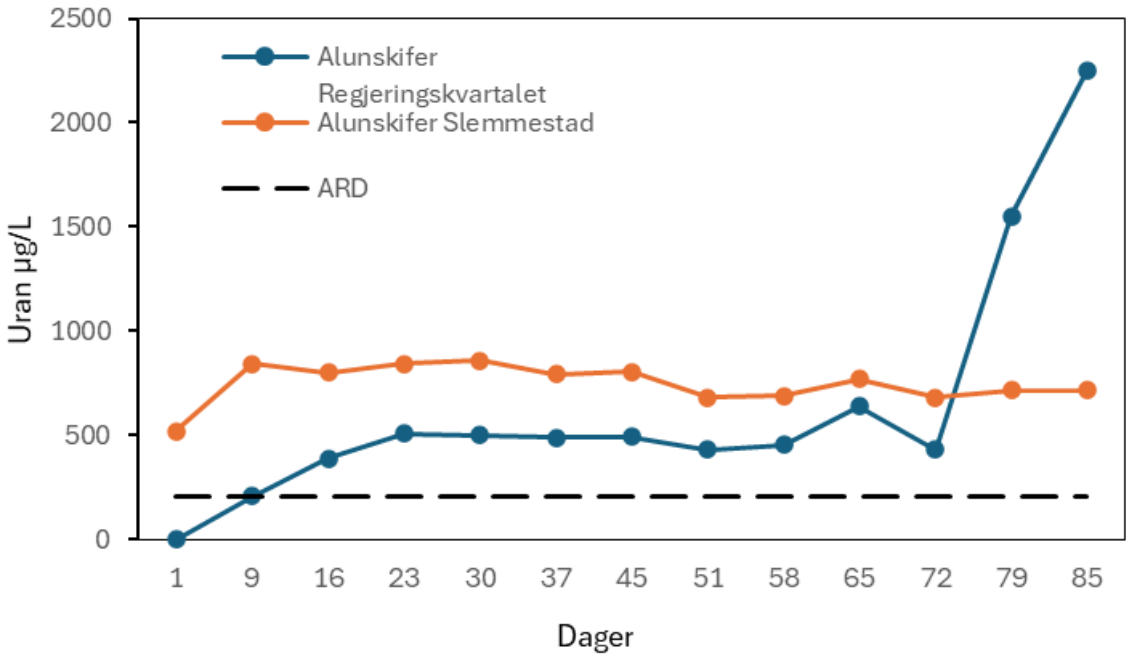
ARD ~ 2.7

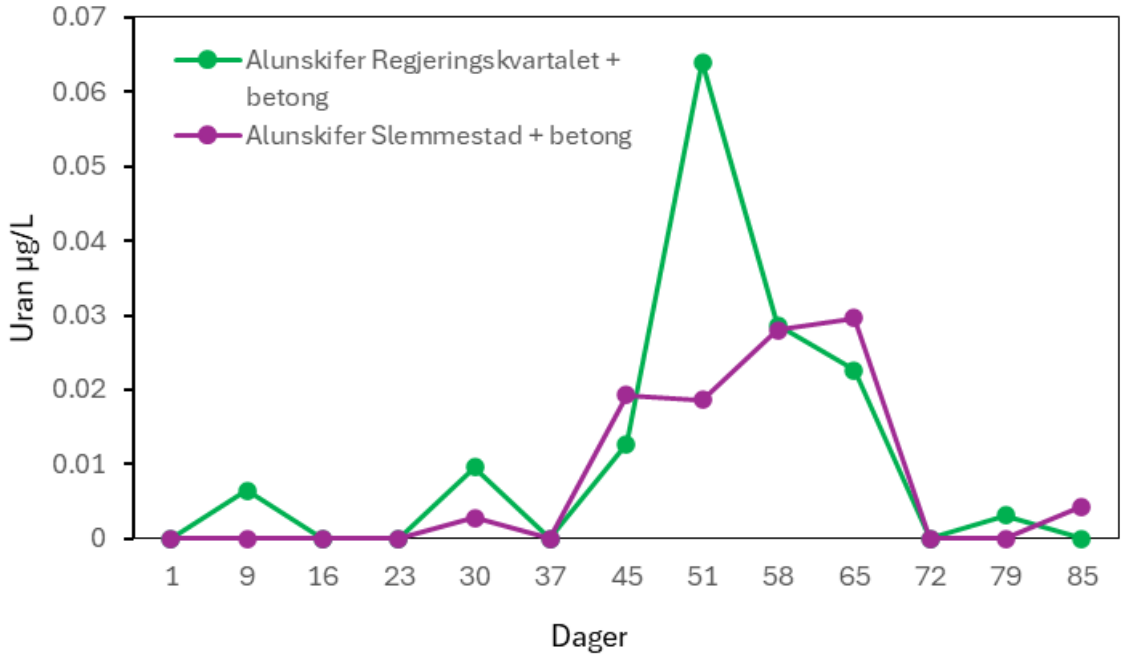
Alunskifer + betong ~ 12.5

Betong + ARD ~ 12.5

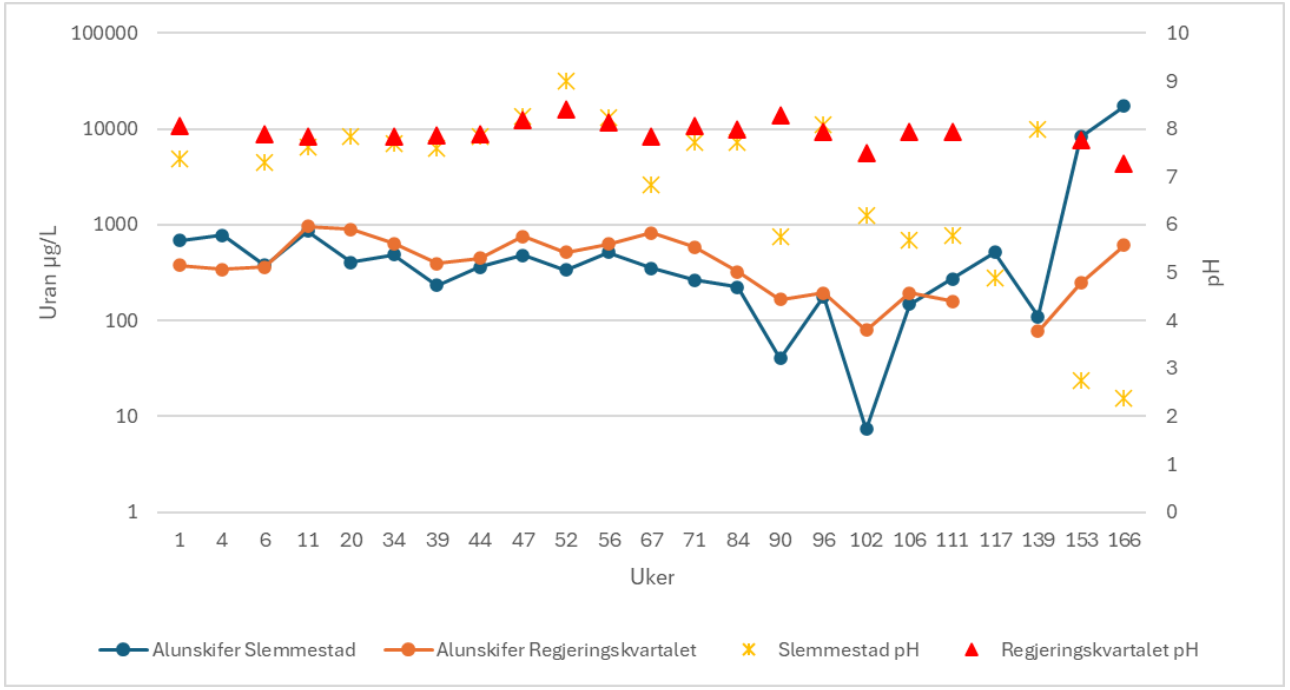


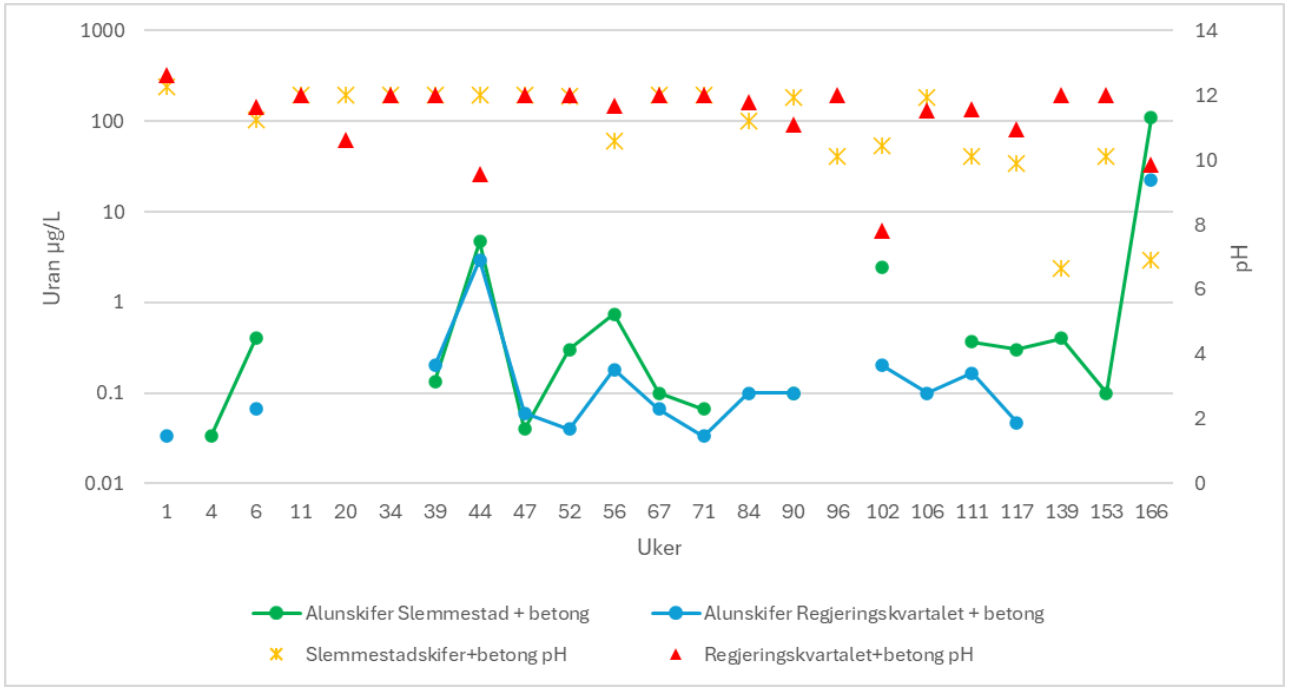
Resulteter lab





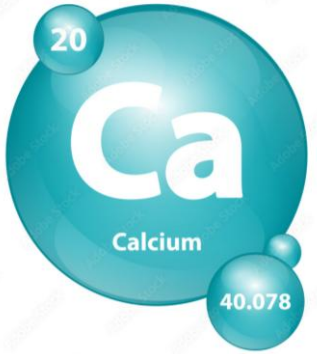
Resultater felt

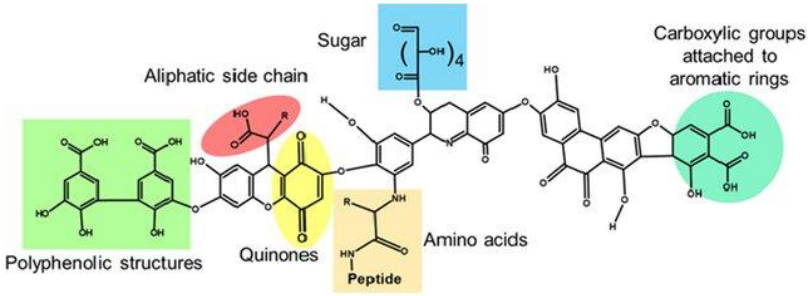




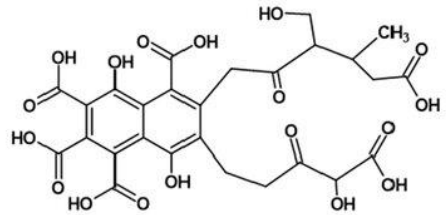
Mulige forklaringer

- Dannelse av kalsium–uranyl–karbonat-mineraler og/eller samsutfelling med kalsitt
- Organiske komplekser kan danne stabile bindinger med uranyl og redusere mobilitet





Humic acid



Fulvic acid

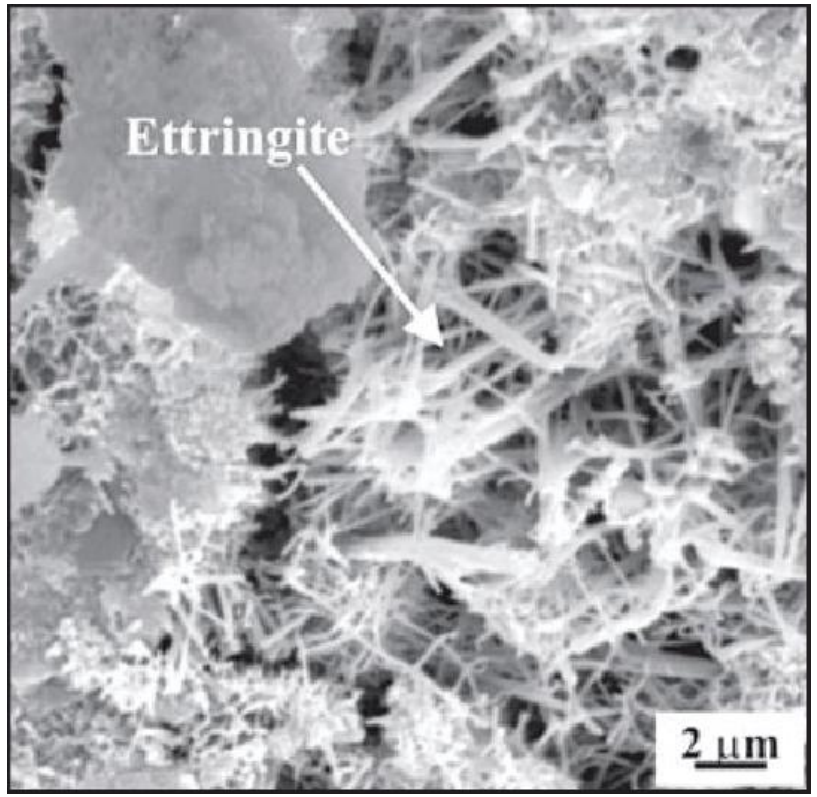
Sutradhar, S., Fatehi, P. Latest development in the fabrication and use of lignin-derived humic acid. *Biotechnol Biofuels* **16**, 38 (2023).
Weber J. Definition of soil organic matter. Humintech: Humic acidsbased products 2002.

Mulige forklaringer

- Uran kan også bindes til C-S-H-faser eller til ettringittstrukturen ($Ca_6Al_2(SO_4)_3(OH)_{12}\cdot 26H_2O$) i sement som Ca–uranyl-hydroksid

  - **C-S-H-faser** = *Calcium–Silicate–Hydrate*.
  - De viktigste hydratiseringsproduktene når sement reagerer med vann
  - Hoveddelen av den herdede sementpastaen.

  - **Ettringitt** dannes i portlandsement når trikalsiumaluminat ($3CaO\cdot Al_2O_3$) reagerer med gips ($CaSO_4\cdot 2H_2O$) under hydratisering
  - Dannelsen fortsetter så lenge sulfat er tilgjengelig



Gemelli, E., Lourenci, S., Folgueras, M., & Camargo, N. (2004). Assessment ofindustrial wastes in mortar layers deposited on stainless steel sheets of sinks. Cerâmica,50(316), 336-344

Hva kan dette brukes til og hva mer må vi vite

- Innblanding eller filterlag ved deponering
- In situ remediering av uranholdige masser

- Hvor lenge fungerer det (bufferkapasitet)?
- Praktiske hensyn
- Kostnader

Takk for meg!

So YOU'RE FEELING USELESS?
THIS CIRCULAR ECONOMY-THING IS REALLY MAKING ME OBSOLETE...
LECTRR