STRUCTURED ADSORBENTS for Cr Removal and Recovery

- **Main objective**
  - **Removal of heavy metals (Cr)** as a posttreatment technology → water reuse
  - **Resource recovery (Cr)**

Uses Cr salts as tanning substance[1]

1.Abreu, Ceramics International, 2009, 35(6), 2225-2234
2.EPA (Safe Drinking Water Act)
https://www.epa.gov/sdwa/chromium-drinking-water

→ pH ~neutral and Cr^{3+} & Cr^{6+} (CrO_4^{2-})
→ wastewater discharge limit for Chromium is 100 ppb (100µg/L)[2].

Adsorption using **Structured sorbents** = key technology to recover/remove **low** concentrations of valuables/undesirable compounds from complex, low-grade matrices

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Design of Structured sorbents with specific composition designed (at VITO):

- Granulated composites prepared by intensive mixing technique:

LDH
Water
(colloidal SiO_2)
Bentonite

Calcination
@ 550°C

- Different ratios (LDH/B)
- Different porosities
- Different granulate sizes

→ pH ~neutral and Cr^{3+} & Cr^{6+} (CrO_4^{2-})

✓ Cr^{6+} → LDH type clay
✓ Cr^{3+} → Bentonite - Phyllosilicate type clay

	Sorbent 1 (S80/20)	Sorbent 2 (S50/50)	Sorbent 3 (S20/80)
Target Cr species	Cr^{3+}/Cr^{6+} Mainly Cr^{6+}	Cr^{3+}/Cr^{6+} Both in equal proportions	Cr^{3+}/Cr^{6+} Mainly Cr^{3+}

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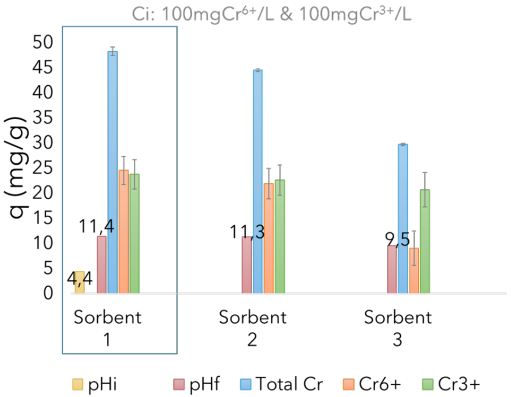
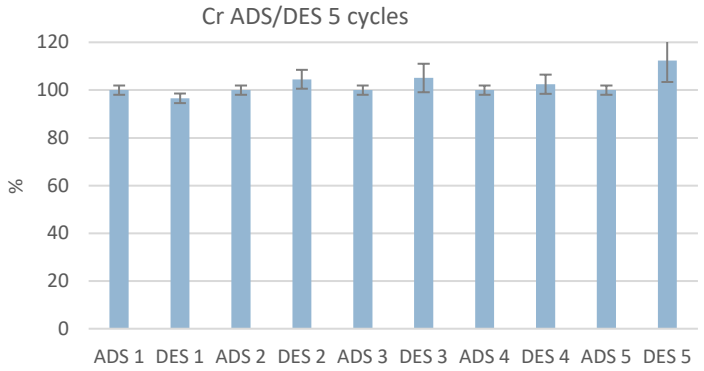
▪ Phase 1: Sorbent composition selection (at VITO)

- Composition screening in synthetic Cr solutions



❖ Sorbent1 selected: 80%LDH:20%Bentonite

- Desorption optimization and multicycle tests:



❖ Optimized desorption solution: 2M NaCl at neutral pH

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- **Phase 2: Testing and Validation (IIT Kanpur)**

Ci: 0.5 – 2 mgCr/L in real permeate (IPC membrane filtration)

Dosages Sorbent 1 (g/100mL)	Removal Efficiency
0.5	49-68 %
0.75	66-78 %
1	77-81 %
1.5	76-87 %
2	91-94 %
2.5	93-96 %

→ At low concentrations, the Cr removal % is dependent of S/L ratio

→ Complete removal can be achieved with increased S/L ratio

→ Kinetics: pseudo 2nd order → calculation of rate constants

→ Results were used for modelling studies and predict the behaviour under flow conditions
→ which indicated that the
U = Hydraulic loading rate ($m^3/m^2/h$)
is the main parameter affecting the column performances

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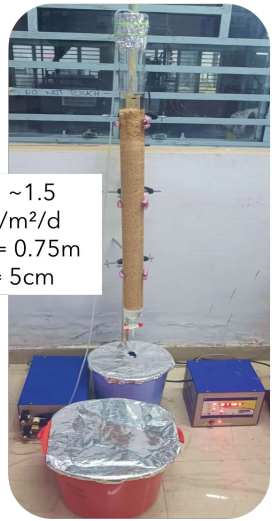
STRUCTURED ADSORBENTS for Cr Removal and Recovery

- **Phase 3: Column design & testing at IIT Kanpur**

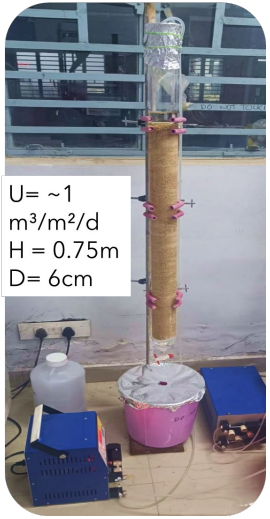
Ci: 1 mgCr/L in real permeate (IPC membrane filtration)

Column 1



U= ~1.5 $m^3/m^2/d$
H = 0.75m
D= 5cm

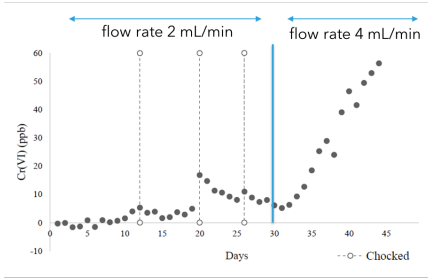
Column 2



U= ~1 $m^3/m^2/d$
H = 0.75m
D= 6cm

Breakthrough curves of Cr(VI) adsorption on structured adsorbent:

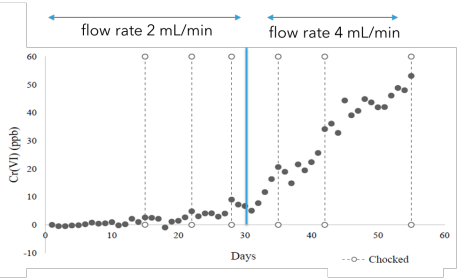
Column 1_D 5cm



Conditions: bed depth 0.75 m: U = 1.5 $m^3/m^2/h$
- pH variation: 8.3-8.6 → 12

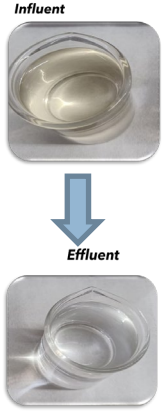
- Breakthrough > 50ppb after ~ 42days
~165 L of wastewater treated

Column 2_D 6cm



Conditions: bed depth 0.75 m; U = 1 $m^3/m^2/h$
- pH variation: 8.3-8.6 → 12

- Breakthrough > 50ppb after ~ 55days
~270 L of wastewater treated



* wastewater discharge limit for Cr is 100 ppb (100µg/L)[1].

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Outcome

- Optimized and validated **composition**: Structured Sorbent 1: 80%LDH:20% Bentonite
- **Multicycle operating** process optimized at small scale: Regeneration by 2M NaCl solution & neutral pH
- The small-scale results allowed the design the larger-scale column set-up and experimental testing

Future research perspectives

- Optimization of operational parameters under flow conditions
- Validation of Multicycle operating process on the larger columns
- Investigation on use/regeneration/disposal of exhausted Structured adsorbents

Opportunity for scale-up

- **Materials:** Structured sorbent production – commercially available clays (LDH & Bentonite) and granulation technique
- **Application:** Possibility to work with larger columns or multiple columns installations

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