**In situ remediation of As, Cd, PFOA and PFOS from soil using graphene-based materials**

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**Background**

Adsorption – common strategy to manage contamination by reducing contaminant mobility and bioavailability, hence alleviating toxicity and risk.

Graphene – novel carbon material; excellent candidate for development as adsorbents due to high surface area and versatile surface chemistry. Demonstrated widely in water/wastewater treatment.

Virtually no studies have investigated the potential of graphene-based materials (GBMs) for *in situ* soil remediation.

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**Aim**

Evaluate the application of GBMs for *in situ* adsorption of soil contaminants.

- Arsenate (As), cadmium (Cd), perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS)
  - multiple contaminant types (i.e., organic, inorganic, cationic, anionic)
  - singly-contaminated vs co-contaminated ‘cocktail’ soils tested.

- Two GBMs – graphene oxide (GO), and an iron-oxide-modified reduced-GO composite (FeG) – were chosen; performance was compared with a commercial adsorbent, RemBind™ (RemB).

- Chemical and biological assessment of ‘remediation’:
  - Effect on bioavailability (extractability) of As, Cd, PFOA and PFOS
  - Effect on microbial-mediated soil nitrification function

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**Experimental Methods**

**Synthesis of GBMs:**
- GO 1 – strong oxidative exfoliation of graphite
- FeG 2 – hydrothermal reduction of GO in the presence of ferrous sulphate

**Determination of EC50 values for soil nitrification:**
- Soil spiking range: As (0.1 – 2500 mg/kg); Cd (0.1 – 1000 mg/kg); PFOA (0.1 – 40 mg/kg); PFOS (0.08 – 225 mg/kg)
- 28 day nitrification incubation test (OECD Test 216)
- Dose-response curves; 50% effect concentrations (EC50)

**In situ soil remediation trial:**
- Contaminant dose based on EC50 concentrations for Ad, Cd, PFOA, PFOS
- Singly-contaminated and co-contaminated soils
- Adsorbent dose = 5% w/w
- ‘Bioavailable’ fractions = 10 mM CaCl2 extracts
- Soil nitrification response = 2 M KCl extracts (nitrate analysis)

**Result**

Impact of As, Cd, PFOA, PFOS on soil nitrification

Dose-response curves; 50% effect concentrations

*Effect on contaminant bioavailability*

As, PFOA, PFOS bioavailability ↓

Cd bioavailability ↑ in GBM-treated soils (low pH and high conductivity)

*Effect on soil nitrification response* (Low soil pH (~ pH 3.5 - 4) responsible for high conductivity)

**Summary**

- As, PFOA, PFOS bioavailability reduction by FeG and RemB (84 - 99%) >> GO (36 - 85%)
- Modification of GO with Fe-mineral phase enhanced performance
- FeG and RemB: mixed mineral + C-based sorbents; multiple binding mechanisms
- Binding sites not saturated
- Acidity of GBMs a challenge (impact soil nitrification function; impede immobilisation of cationic metals like Cd)
- Application in *in situ* for soil remediation requires neutralisation of acidity

**References:**

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