Application of Soil Amendments for Reducing PFAS Exposure and Bioavailability

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PFAS Exposure and Remediation

- High electronegativity
- High bond strength
- Limits oxidation of per-fluoro compounds
- Poly-fluoro compounds (+ precursors) may undergo transformation

![Graph showing PFAS amendment application and costs]
PFAS Exposure and Remediation

**Aim**: Assess the impact of soil amendments on:

1. PFAS leachability
2. PFAS bioavailability

RemBind™ technology, jointly owned by the CSIRO and Ziltek Pty Ltd, has been fully commercialised by Ziltek Pty Ltd (US Patent 8,940,958 B2)

RemBind™: Composite product comprising amorphous aluminium hydroxide, kaolin clay and activated carbon
PFAS Exposure and Remediation – Research Approach

Bench scale immobilisation studies
- RemBind™ formulations
- Application rates

PFAS mobility
- ASLP-DI
- Effect of pH
- MEP

PFAS bioavailability
- In vivo mouse model
- Fate of pure compounds
- Assessment of RBA
PFOS and PFHxS Leachability – Pre- and Post-Amendment

PFOS Leachability in soil Z2

PFHxS Leachability in soil Z2

PFAS (µg l⁻¹; ASLP-DI)

RemBind100
RemBind200
RemBind300

PFOS+PFHxS Interim landfill acceptance criteria (double composite lined (7 µg l⁻¹))

Amendment application (% w/w)
PFAS Bioavailability – Research Approach

- C57BL/6 mice – well established breed
- 10 day exposure study (9 + 1)
- For each treatment – 4 operational units, each comprising 3 mice
- PFAS (0.01-1.0 µg kg\(^{-1}\)), contaminated soil (1% w/w) or amended soil (up to 10% w/w) added to AIN93G chow
- PFAS-AIN93G chow supplied *ad libitum*
- Health, consumption, excretion data monitored daily
- Following exposure, PFAS concentration in tissue / excreta is determined
- Determine dose-response and bioavailability endpoints
- Determine PFAS relative bioavailability in soil using pure compounds as the reference
Assessment of *In Vivo* PFAS Distribution

**PFHxS**
- Liver
- Kidney
- GI
- Faeces
- Urine
- Carcass

**PFOS**
- Liver
- Kidney
- GI
- Faeces
- Urine
- Carcass

**PFBS**
- Liver
- Kidney
- GI
- Faeces
- Urine
- Carcass

**Urineary excretion (µg)**
- PFCA C-chain length

**Liver accumulation (µg)**
- PFCA C-chain length
Assessment of PFAS Bioavailability

- Short-chain PFAS were excreted in the urine; PFCA were excreted to a greater extent than PFSA.
- Urinary excretion decreased with increasing perfluoralkyl chain length.
- PFAS accumulated in the liver; increasing accumulation with increasing carbon chain length was observed for PFCA up to a cut off of C11.
- Linear dose-responses were observed; urinary excretion (PFBS, C4-C6 PFCA), accumulation in organs and / or carcass.
Assessment of PFAS Relative Bioavailability

- PFAS (mg kg⁻¹):
  - PFOA
  - PFHxS
  - PFHpS
  - PFOS
  - 8:2 FTS

- Soil Relative Bioavailability (%):
  - Unamended soil
  - Amended soil
Conclusions

❖ Amendment of PFAS-contaminated soil with Rembind™ (at 5% w/w) reduced PFAS leachability by > 99%
❖ Dose-response studies highlighted differences in PFAS fate in vivo → this has implications for bioavailability endpoint monitoring.
❖ PFAS RBA in contaminated soil was reduced by > 75% when soil was amended with 5% w/w Rembind™.
❖ Future research includes the development of new Rembind™ formulations that can further reduce PFAS RBA.

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