Mycoremediation

Mushrooms for more than just food

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BEST
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Outline

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- Science of Mycoremediation
- Design Considerations
- Bench-scale testing
  - Greasy soil
  - Land treatment area
  - Former Biotreated site
- Summary

Chemical Remediation

Stabilization & Sequestration

Bioremediation

Thermal Extraction & Recovery

Intro

- Oskar Pula, M.Sc., P.Ag.
- >12 years in Environment
    - Focus on soil and groundwater remediation
    - General Manager with TRIUM
        - Client relationship management
        - Design remediation programs
        - Over-see Operations and project
        - Identify areas for operational efficiency/ diversification
- NOT A MYCOLOGIST, I just think Mycoremediation is cool!

Intro

- TRIUM Environmental
  - Established in 2006 with a focus on ChemOx
  - Continue to operate as a remediation technology and application specialist
  - R&D initiatives to identify new remediation opportunity
    - Chemical
    - Physical
    - Biological (Myco)

Mushroom Background

- Mushrooms are a fungus
- Mycelium makes up majority
- Mycelium acts as connection (mycorrhizae) for plants/ trees
  - Water and nutrient transport
  - Carbohydrate for fungus
- Rich source of fibre, protein, and antioxidants (selenium)
  - Superfood
  - Ontario and BC account for 92% of Canadian production (110M kg, 2017)

Science of Mycoremediation

- Mycoremediation - bioremediation technique utilizing fungi to break down contaminants or absorb contaminants within the body of the mycelium and fungal fruit (ie/ mushrooms).
- White rot fungi breaks down lignin, a complex organic polymer, which has similar structure to heavy end hydrocarbons
  - The white rot fungi uses the organics as a carbohydrate, with end products being CO_2 and water
- As a natural process for remediation, Naturo-EXF is a sustainable solution that destroys contaminants, has little to no operational maintenance, and can improve soil structure

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Design Considerations

- Location
- Moisture/ humidity
- pH
- Nutrients
    - C:N loading
- Temperature
- Light

Bench-scale testing – Greasy Soil

- Problem – Soil characterized as hydrophobic and heavy hydrocarbon impacts
  - Client opting for on-site treatment options incl. biological, thermal, and chemical
  - Thermal treatment to be used for "Worst case soils" and alternative treatment for remaining soil
- Based on contaminants of concern, Myco was considered as an option (F3, F4, PAH)

Bench-scale testing – Greasy Soil

- Benchscale testing completed using 3 different dosings
  - Completed in triplicates for statistical analysis
  - Total treatment time was 8 weeks

Bench-scale testing – Greasy Soil

- Significant reductions of PAH's observed
- Greatest reductions observed in highest dosing
- Overall, linear growth trend shown in reductions as myco dosings increased
  - Lower dosings would likely have similar reductions but would require more time for treatment in order to achieve full reductions
- Up to 100% reduction seen in select PAH's following 2 months of treatment. Average reduction in dosings was:
  - Low dosing (Dosing 1) – 43%
  - Moderate dosing (Dosing 2) – 58%
  - High dosing (Dosing 3) – 75%
- Of the 11 PAH parameters exceeding applicable guidelines in baseline data, only 5 remained greater than guidelines but were only marginally greater than guidelines
- Testing indicates if time is not critical to closure, lower dosing can be applied

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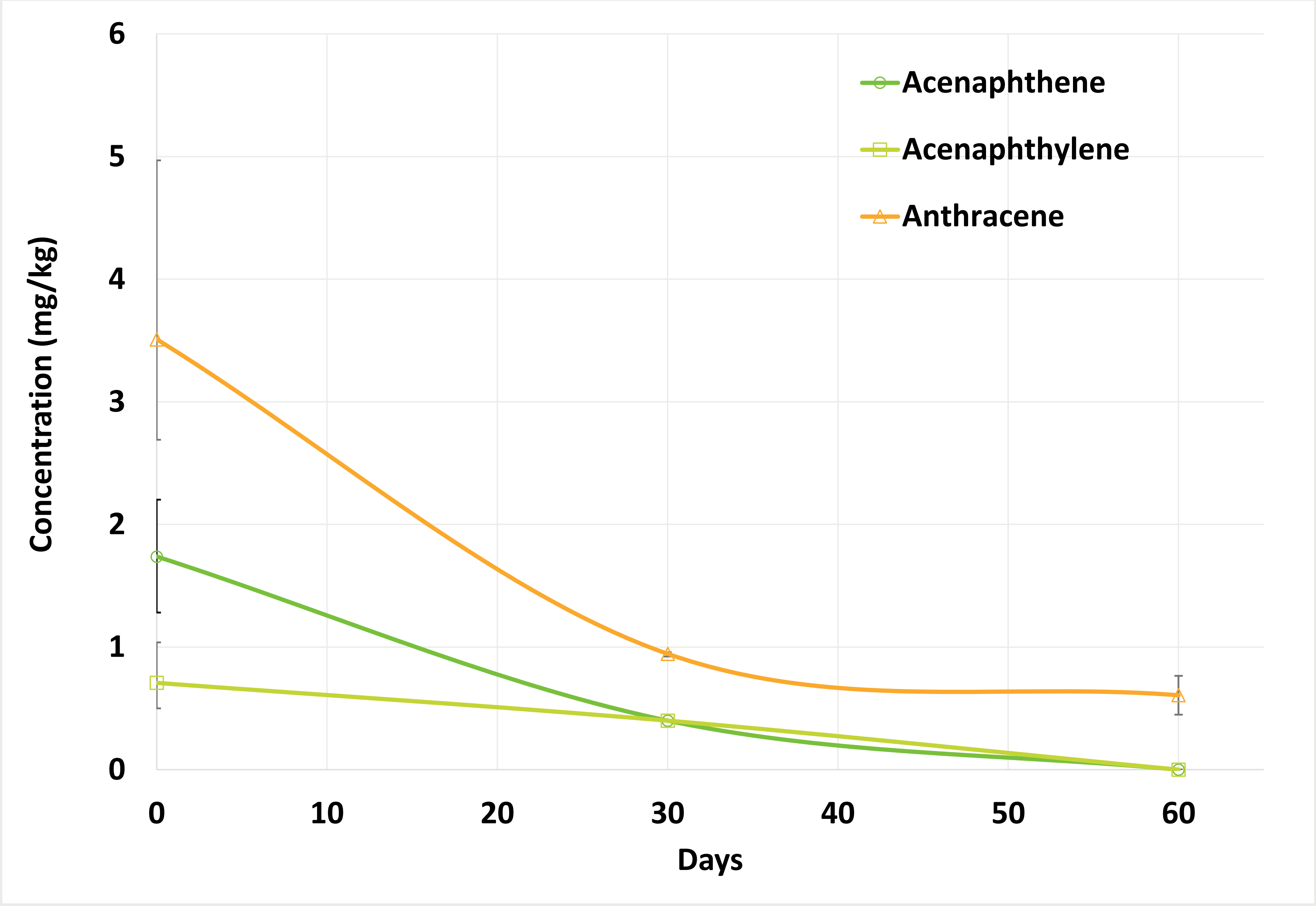
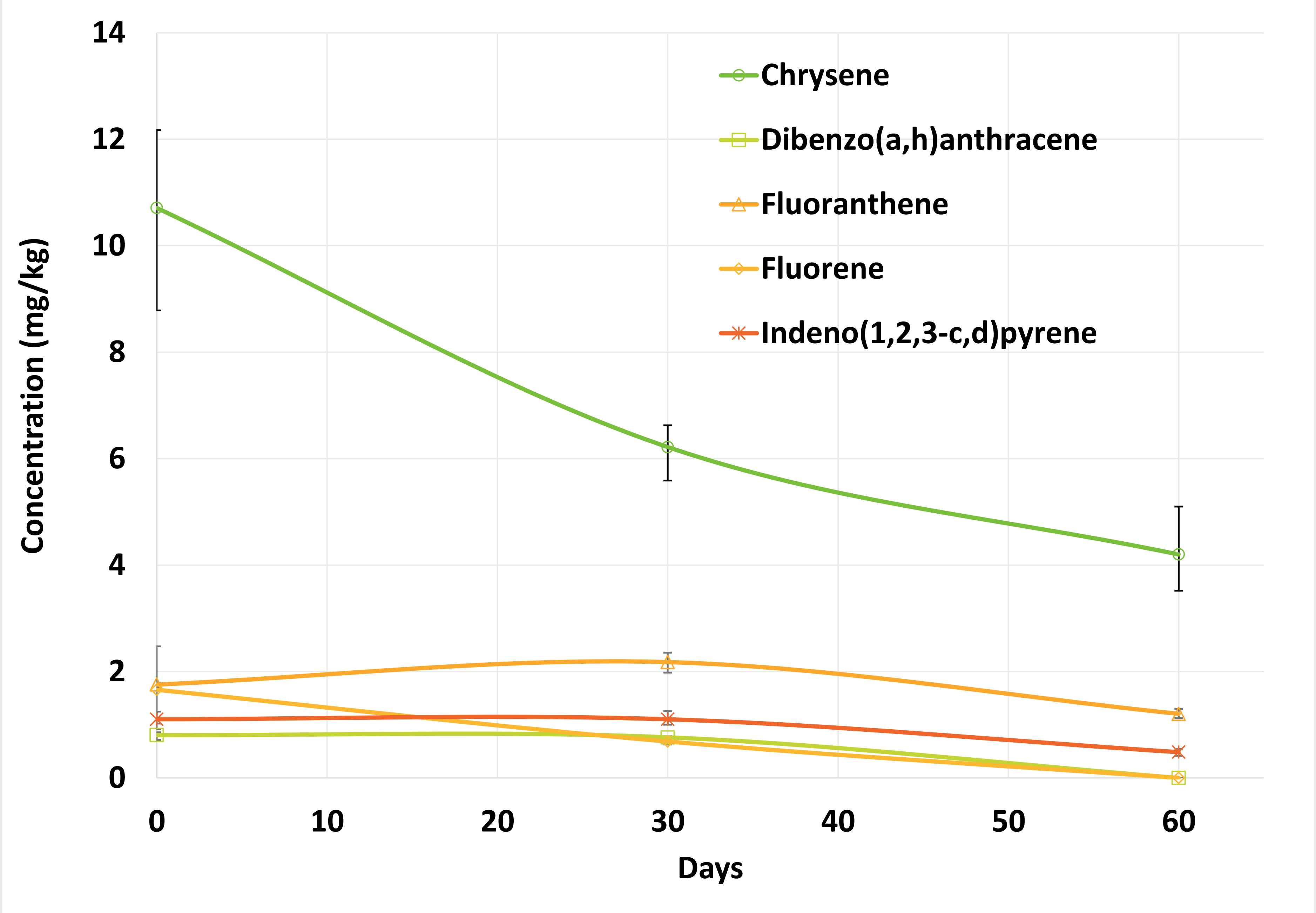
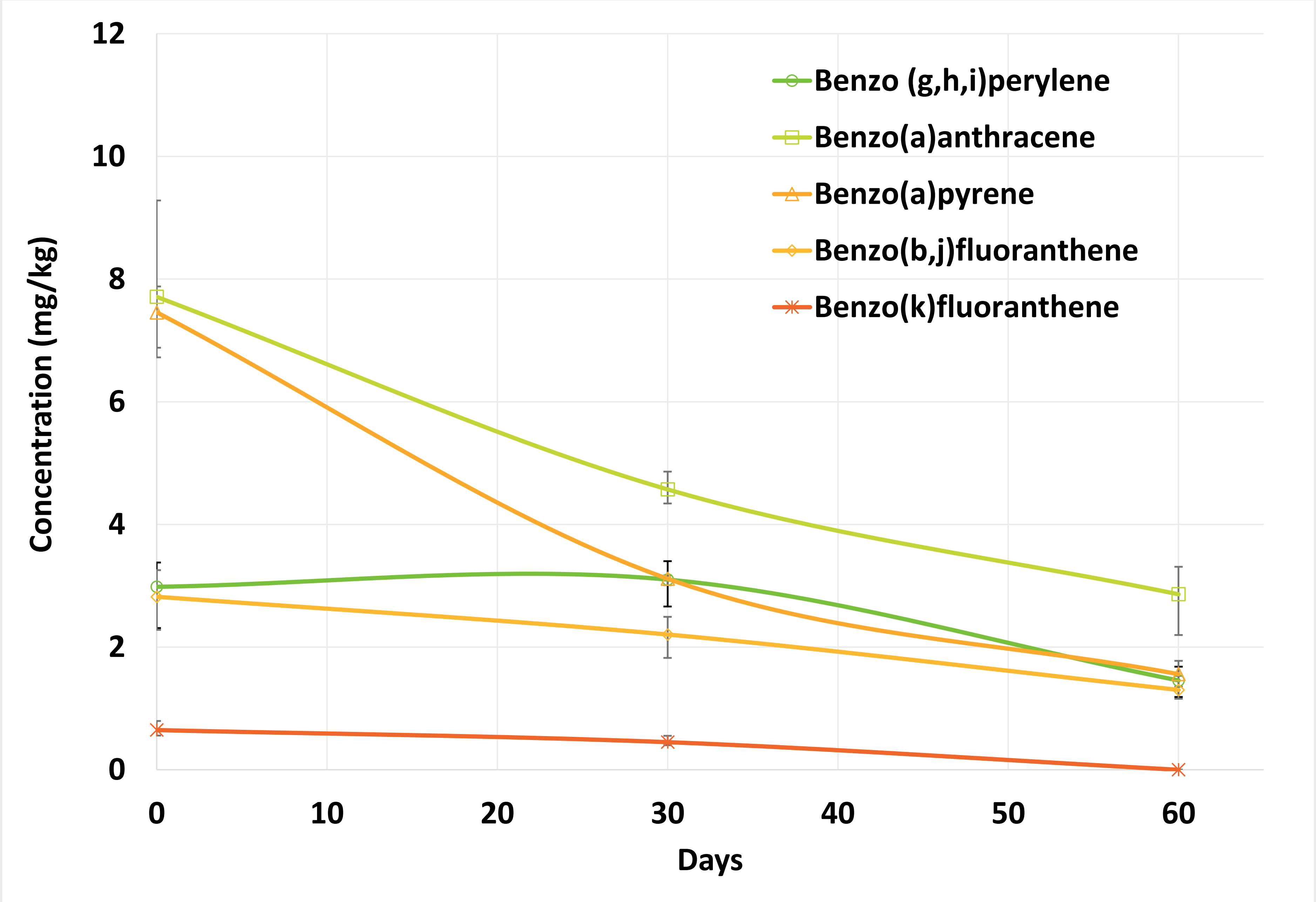
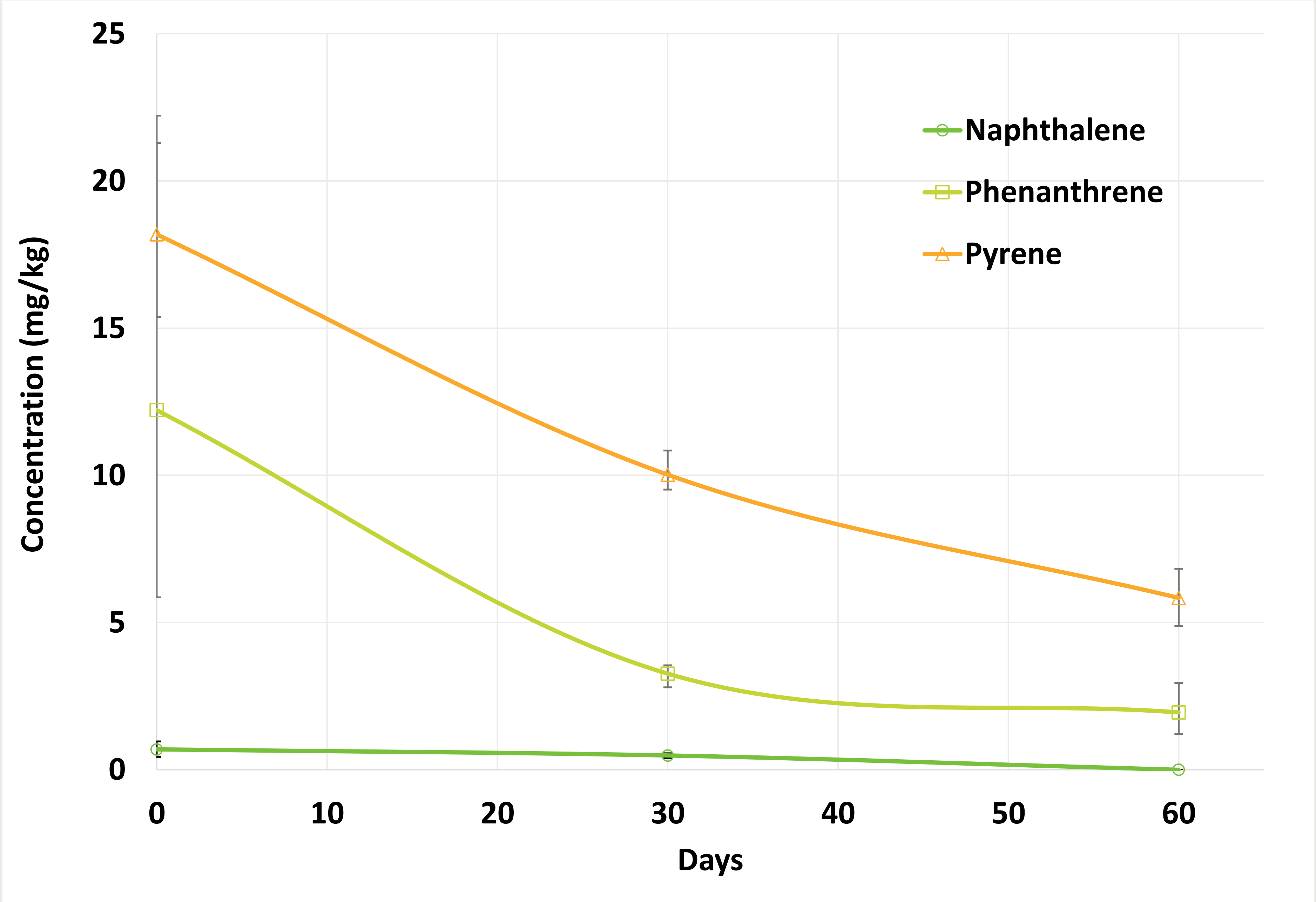
Greasy Soil – PAH Analysis

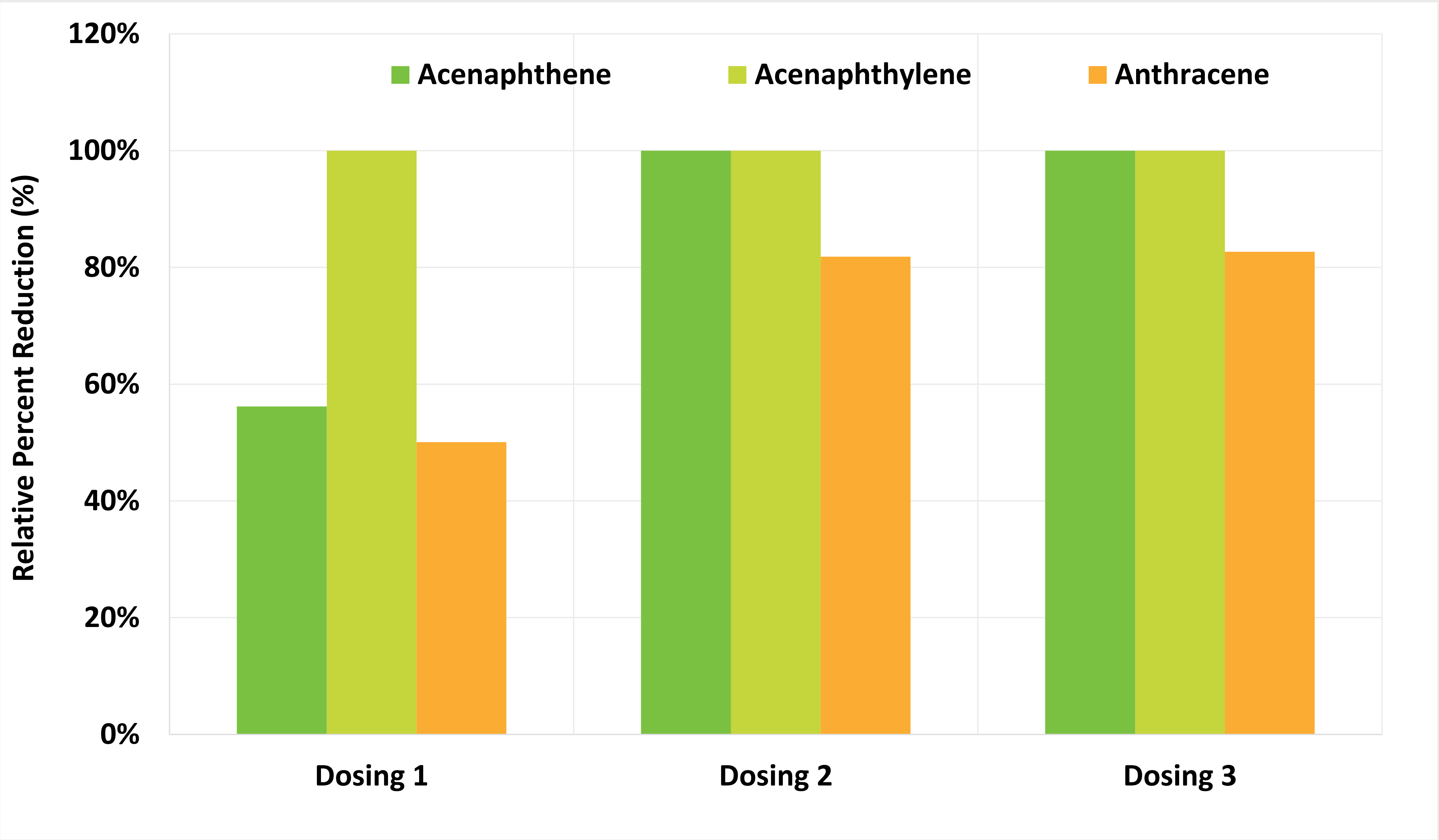


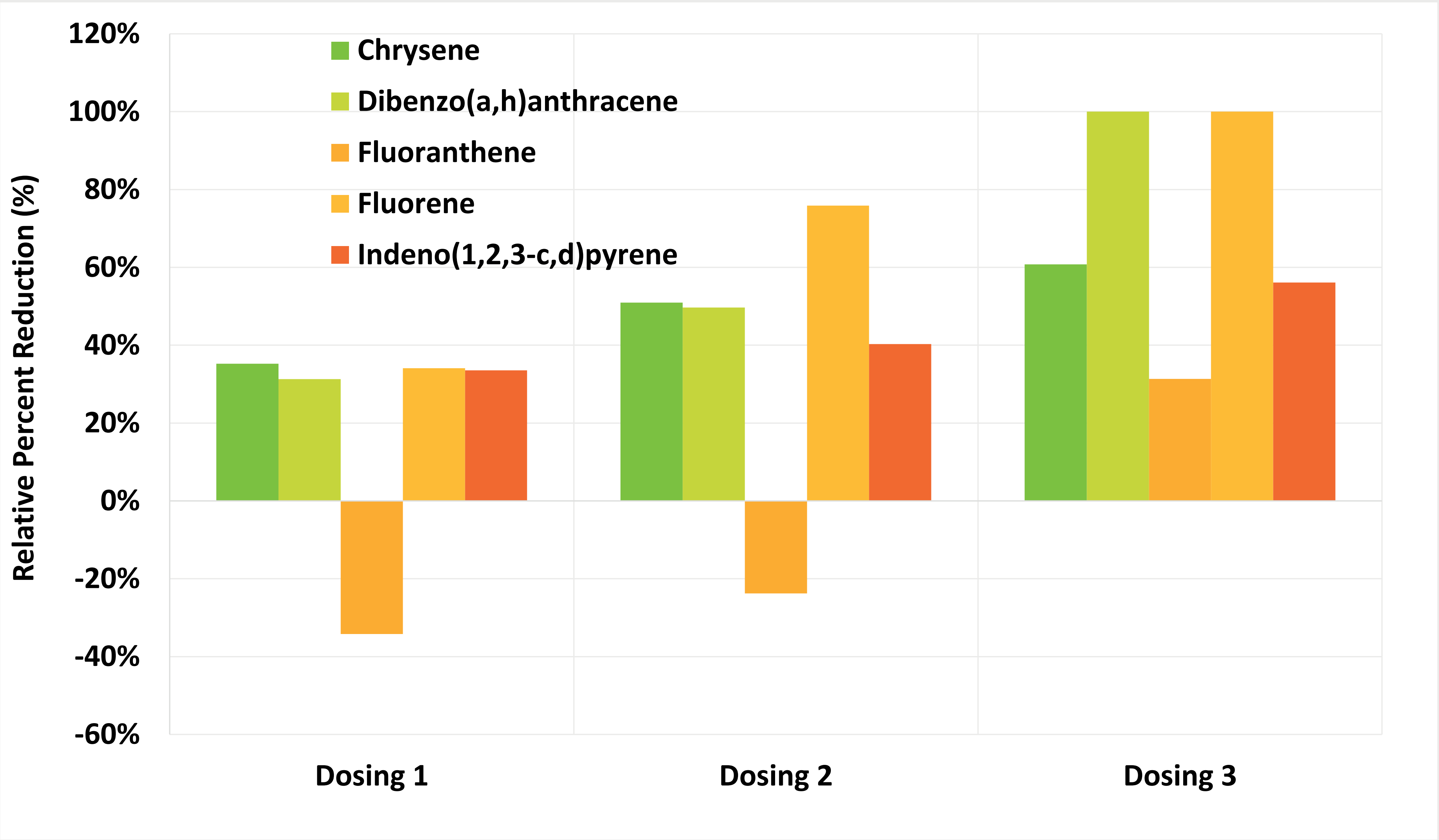


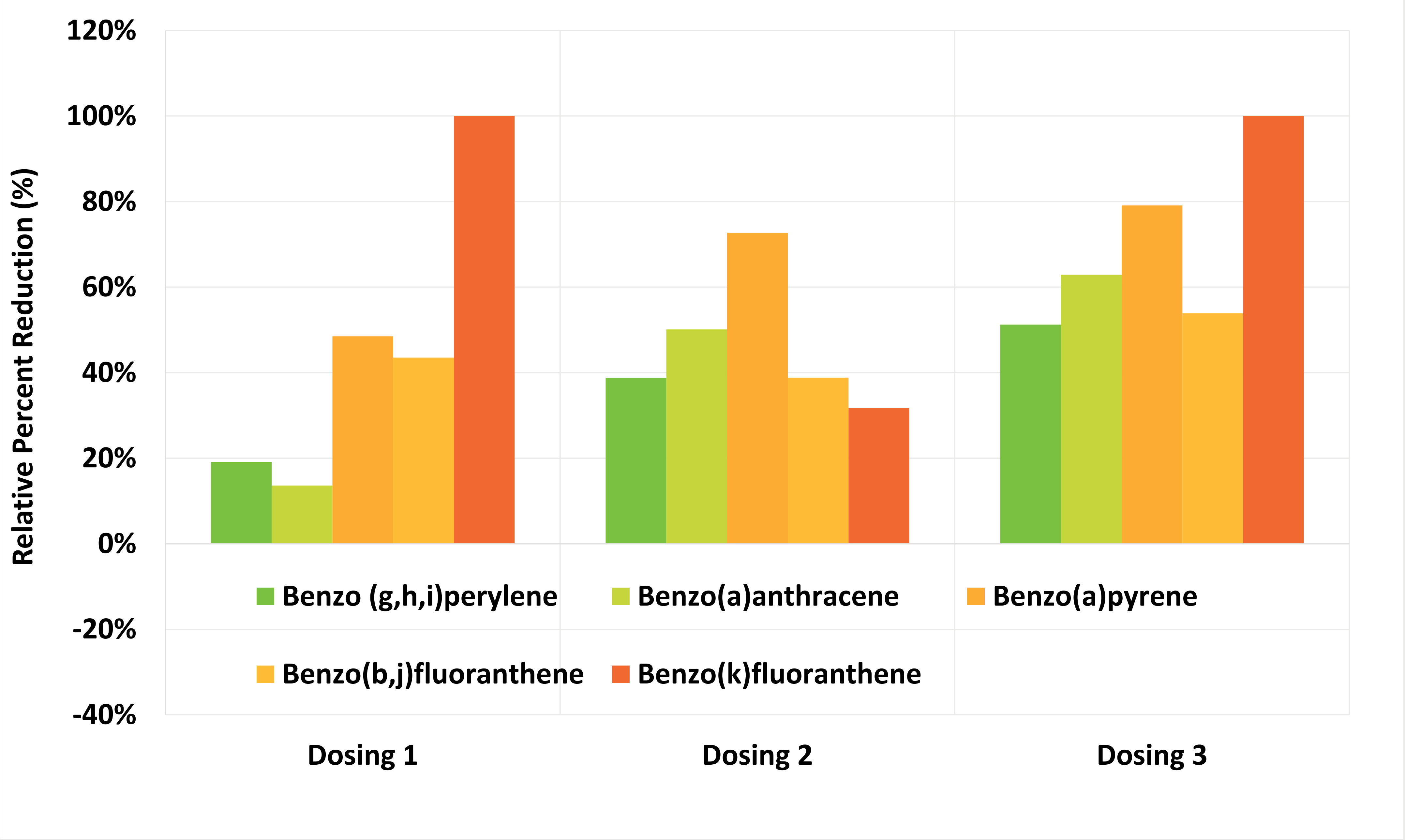


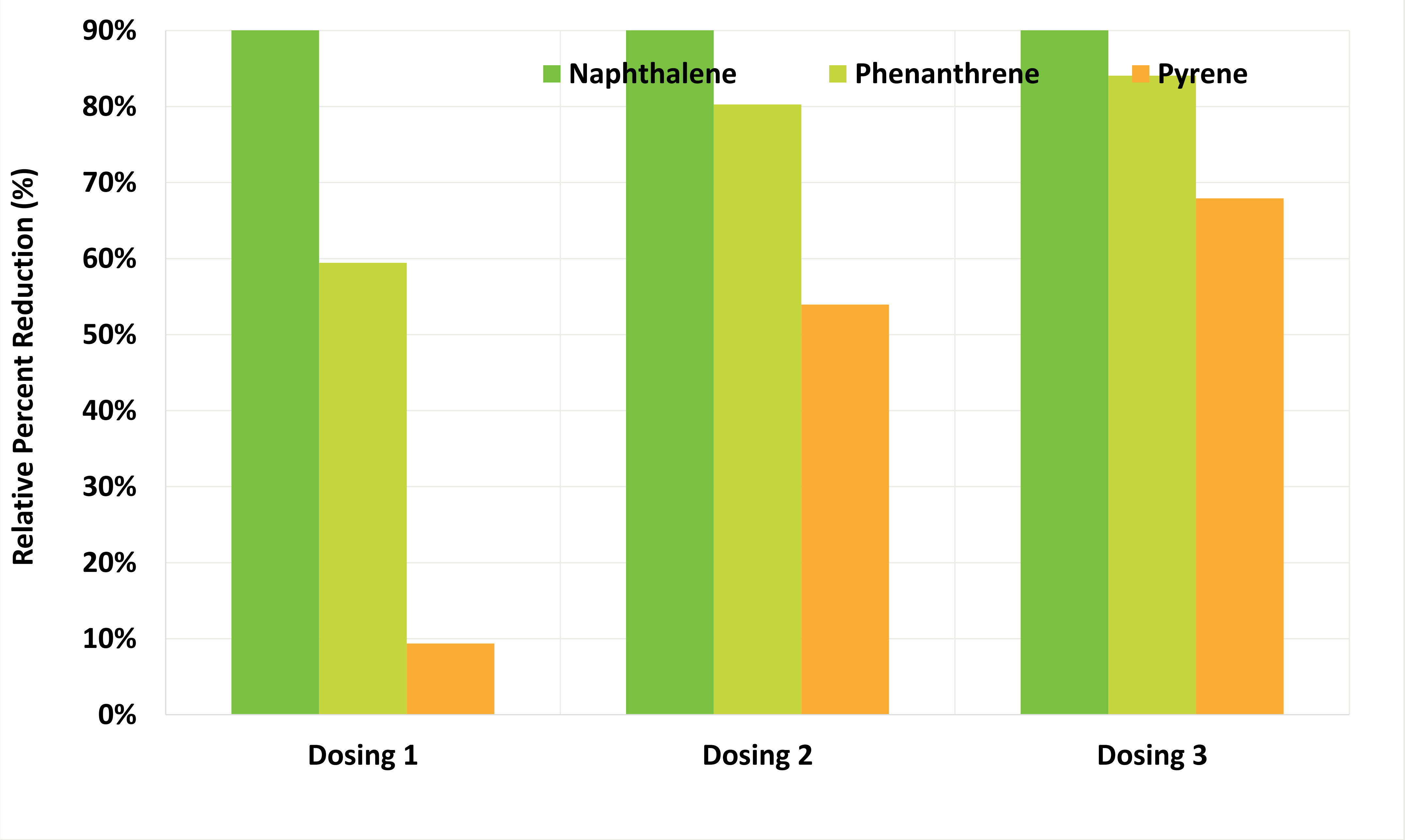


Greasy Soil – PAH Analysis

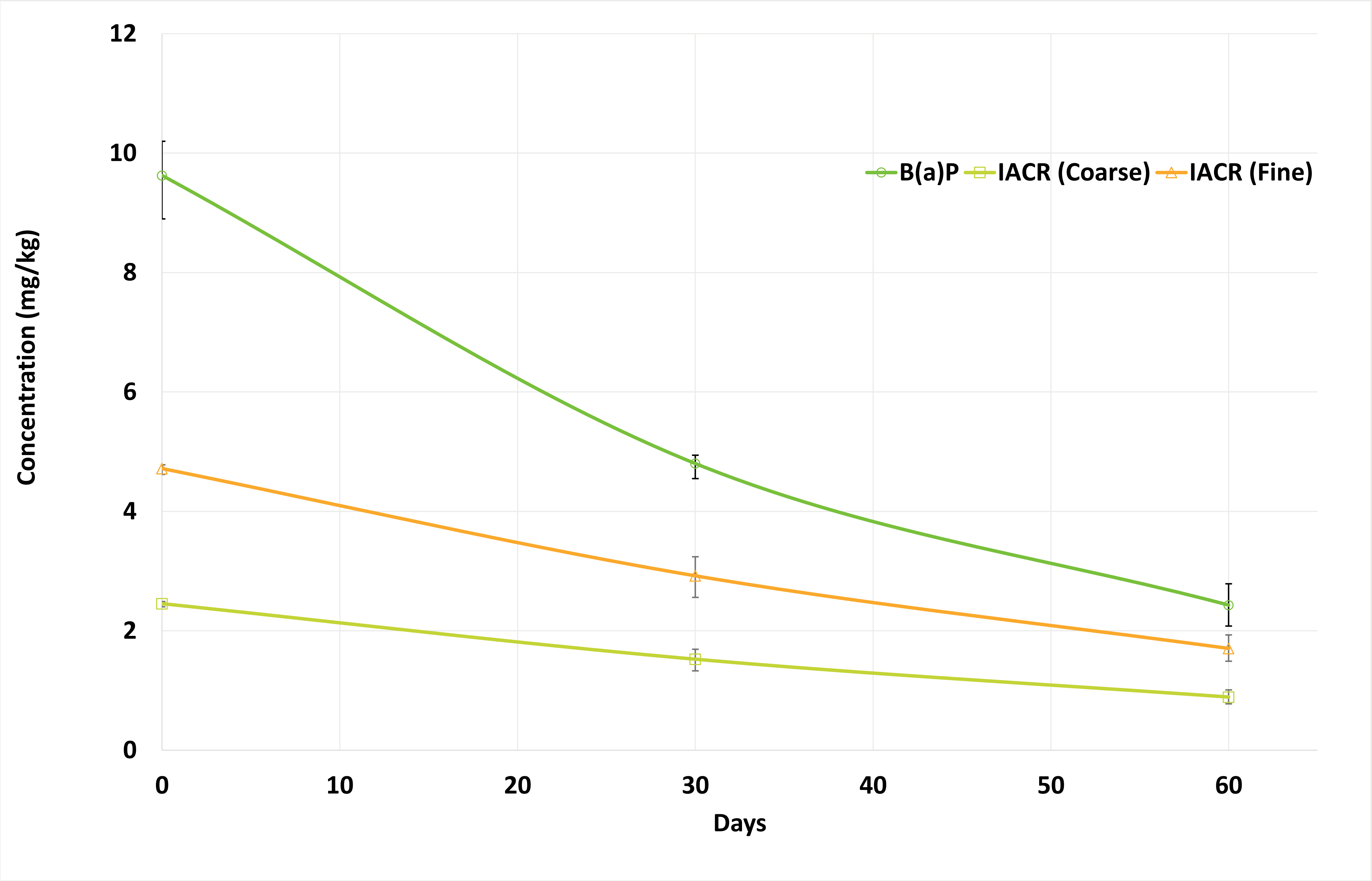








Greasy Soil – PAH Analysis



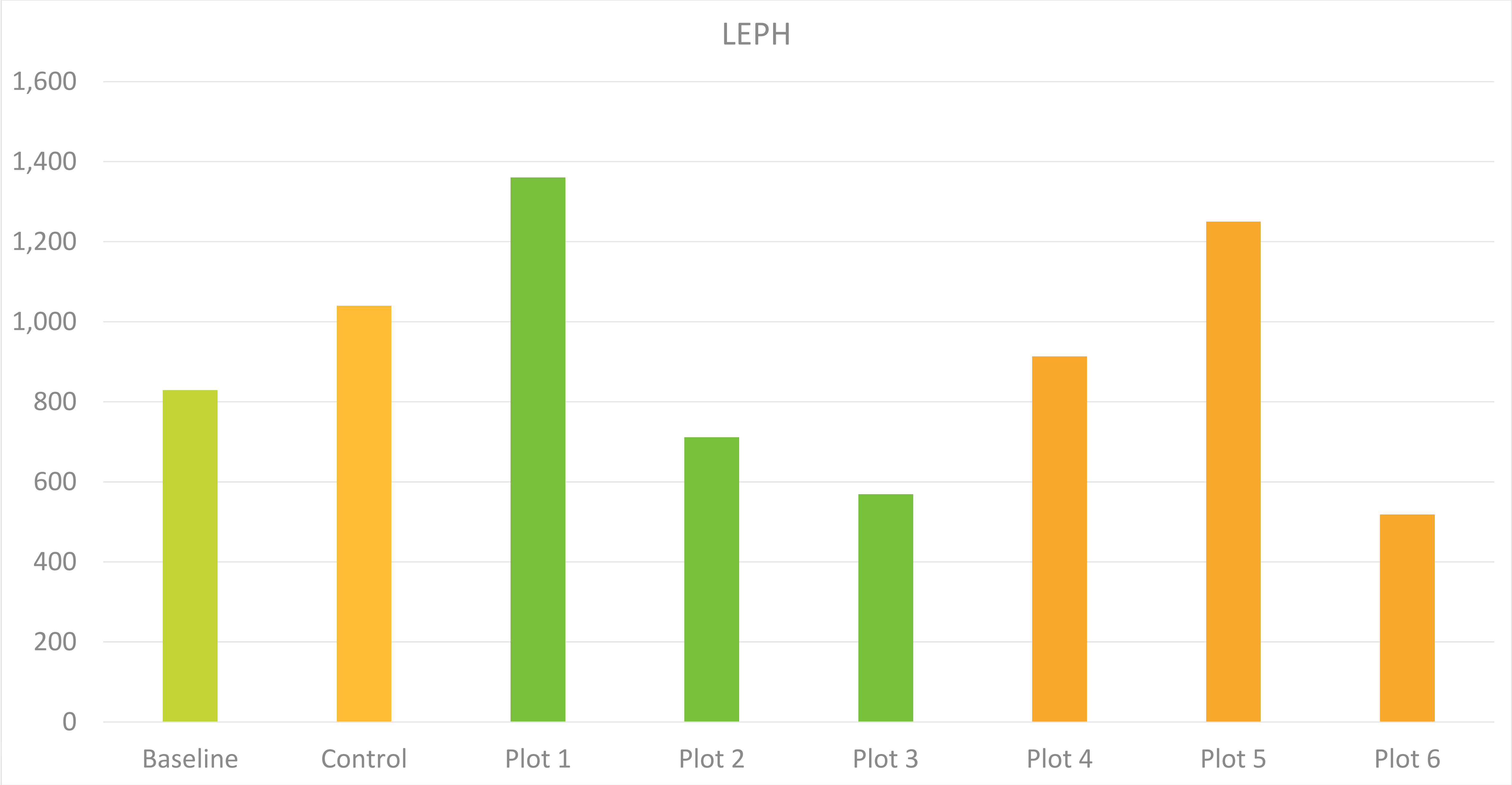
Bench-scale testing – Land Treatment Area

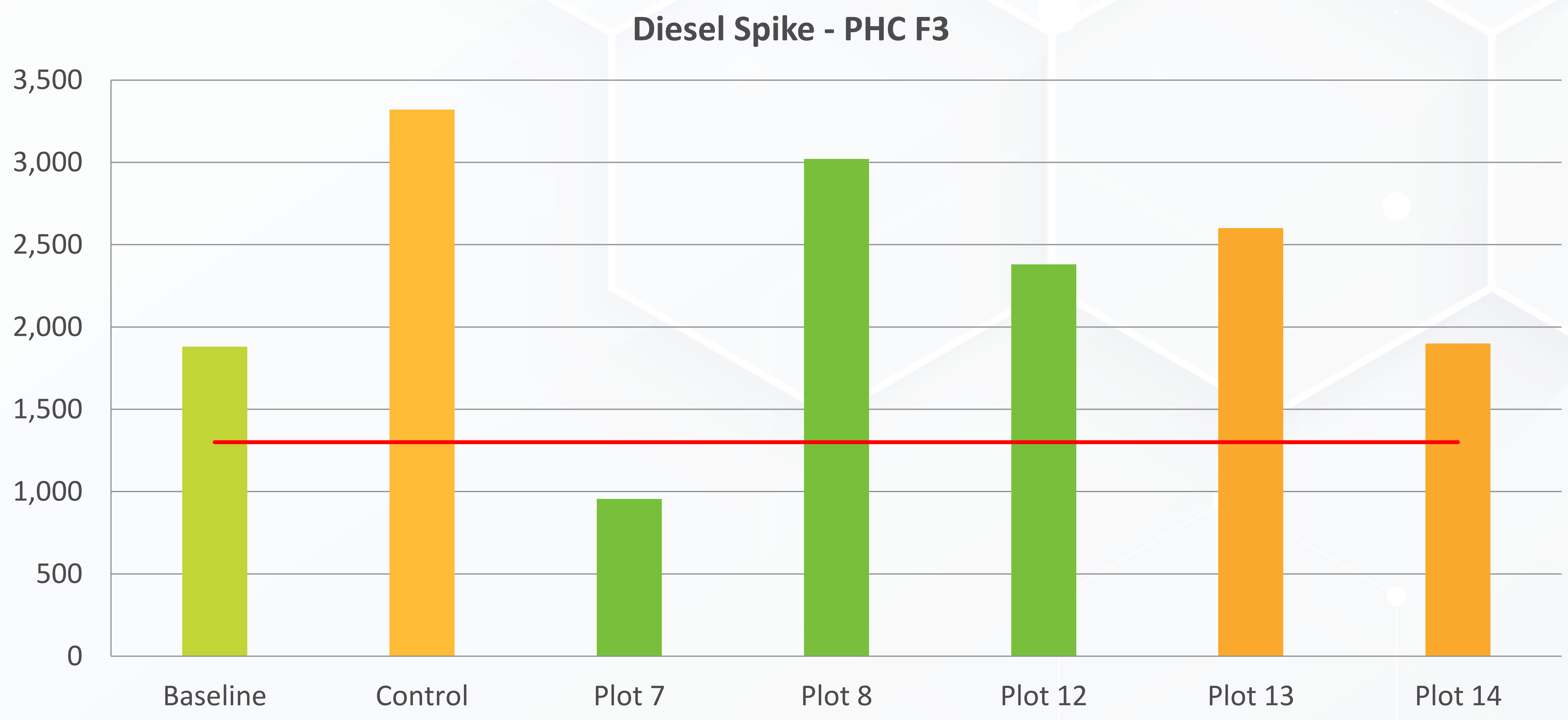
- Problem – Former drilling waste disposal area with fine grained soil and heavy hydrocarbon impacts
  - Client opting for on-site treatment options incl. biological, thermal, and chemical
  - Centralized treatment facility to be considered for future
- Based on contaminants of concern, Myco was considered as an option (EPH, LEPH, PAH)

Bench-scale testing – Land Treatment Area

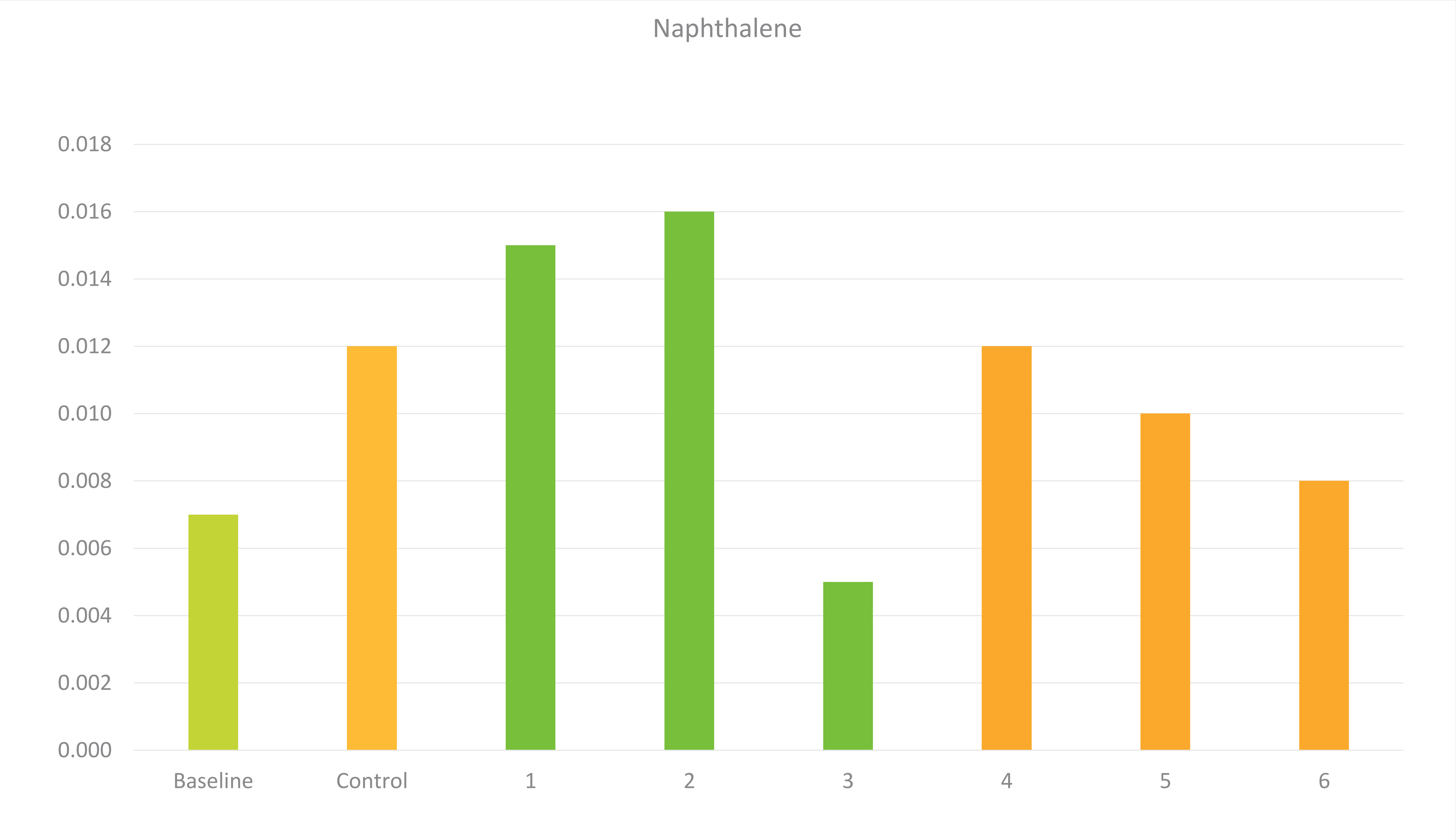
- Benchscale testing completed using 3 different dosings, 2 different spawns, and diesel spikes
  - Completed in duplicates
  - Total treatment time was 8 weeks

Land Treatment Area – PHC Analysis





Land Treatment Area – PAH Analysis



Bench-scale testing – Former Biotreated Site

Problem – Site has undergone bioremediation to address low level PAH, but residual impacts remain after 5 years treatment

Client would like to treat soils for future use

Based on contaminants of concern, Myco was considered as an option (F3 and PAH – Naphthalene)

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Bench-scale testing – Former Biotreated Site

- Benchscale testing completed using 6 plots of $1m^3$:
  - Control (A)
  - Grain spawn (B)
  - Grain spawn & Nutrients (C)
  - Nutrients only (D)
  - Grain spawn and straw (E)
  - Grain spawn and sawdust (F)

- Composite samples were collected:
  - Pre-treatment
  - 1 month post treatment
  - 2 months post treatment
  - 3 months post treatment

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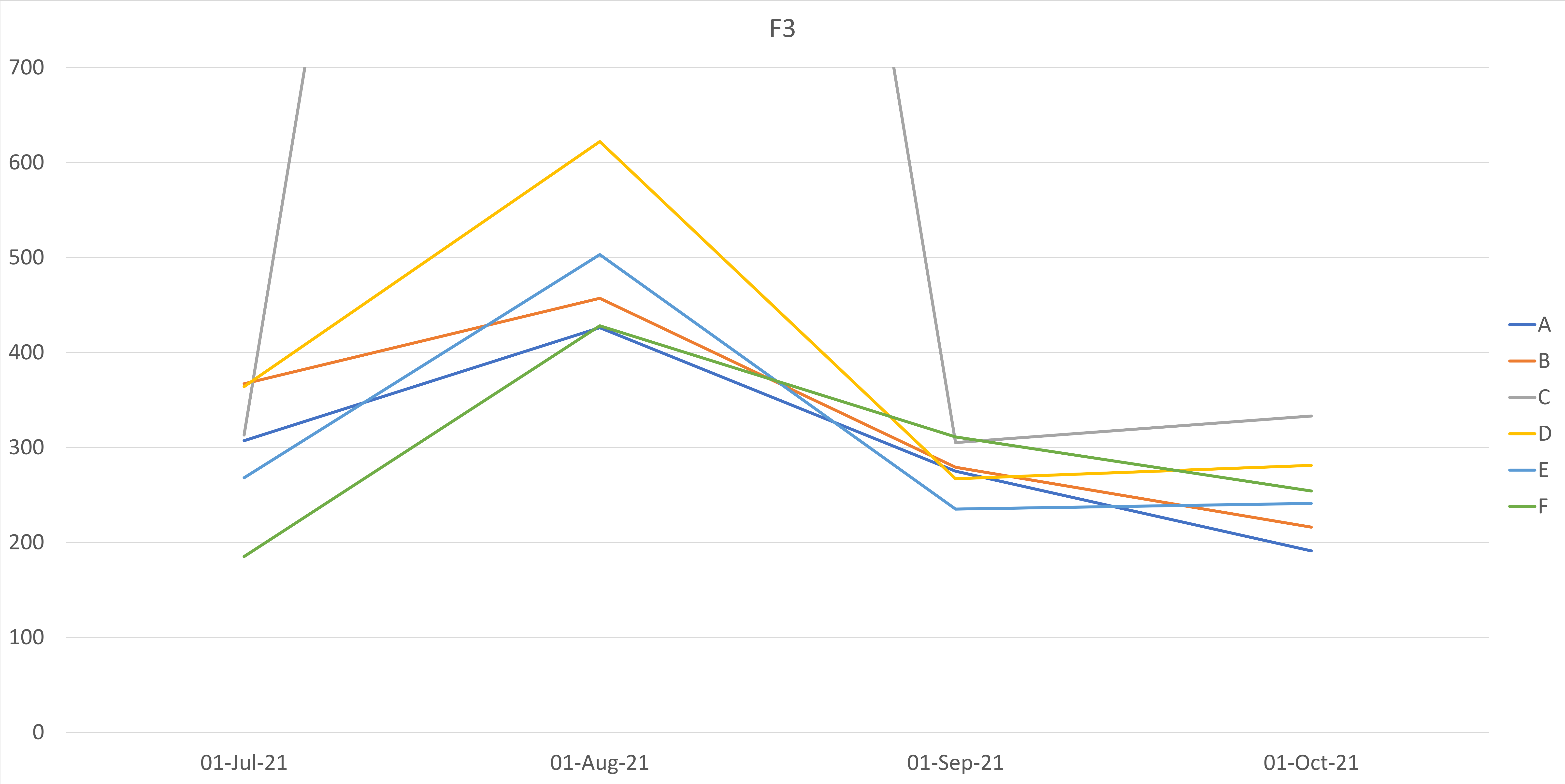
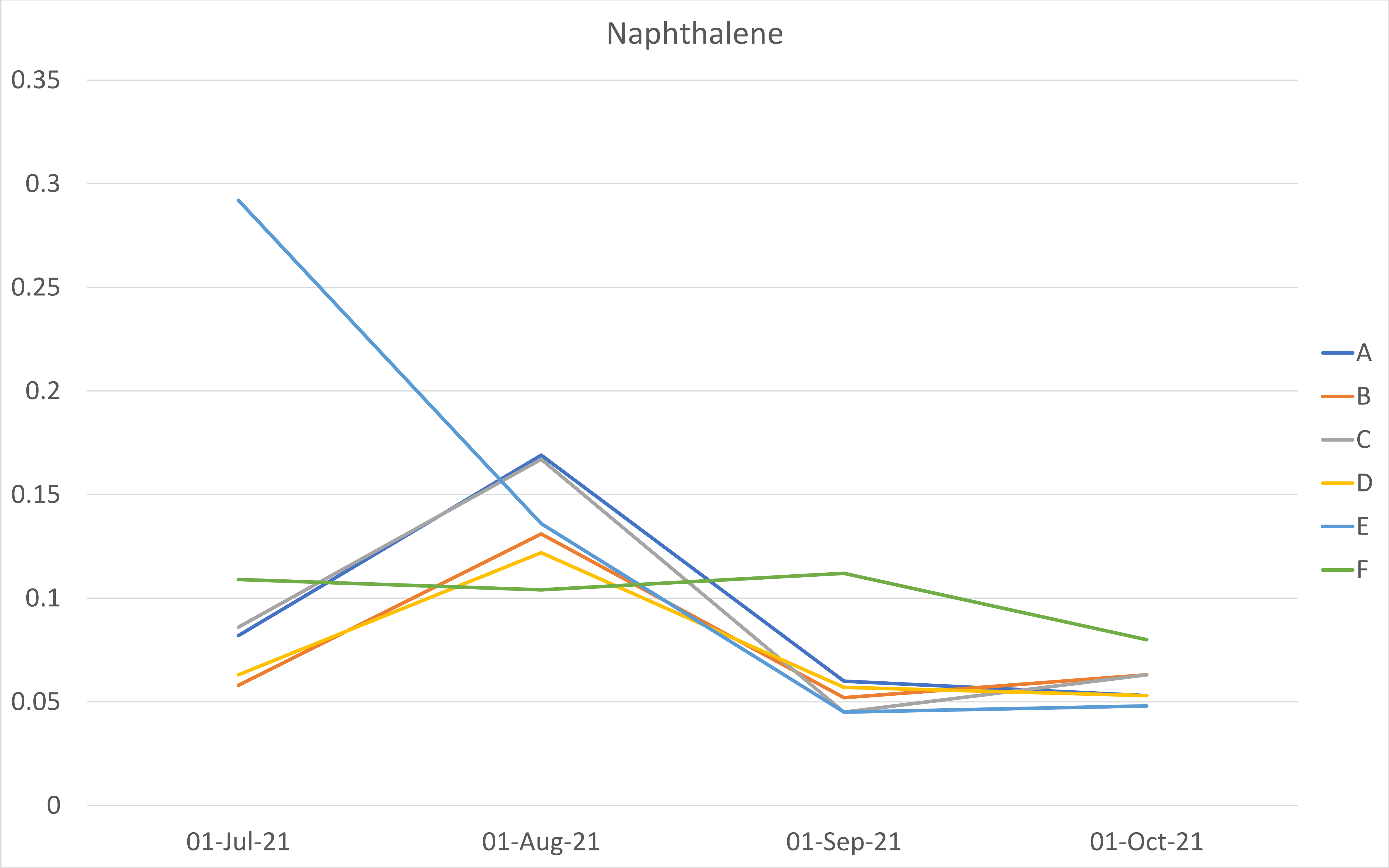
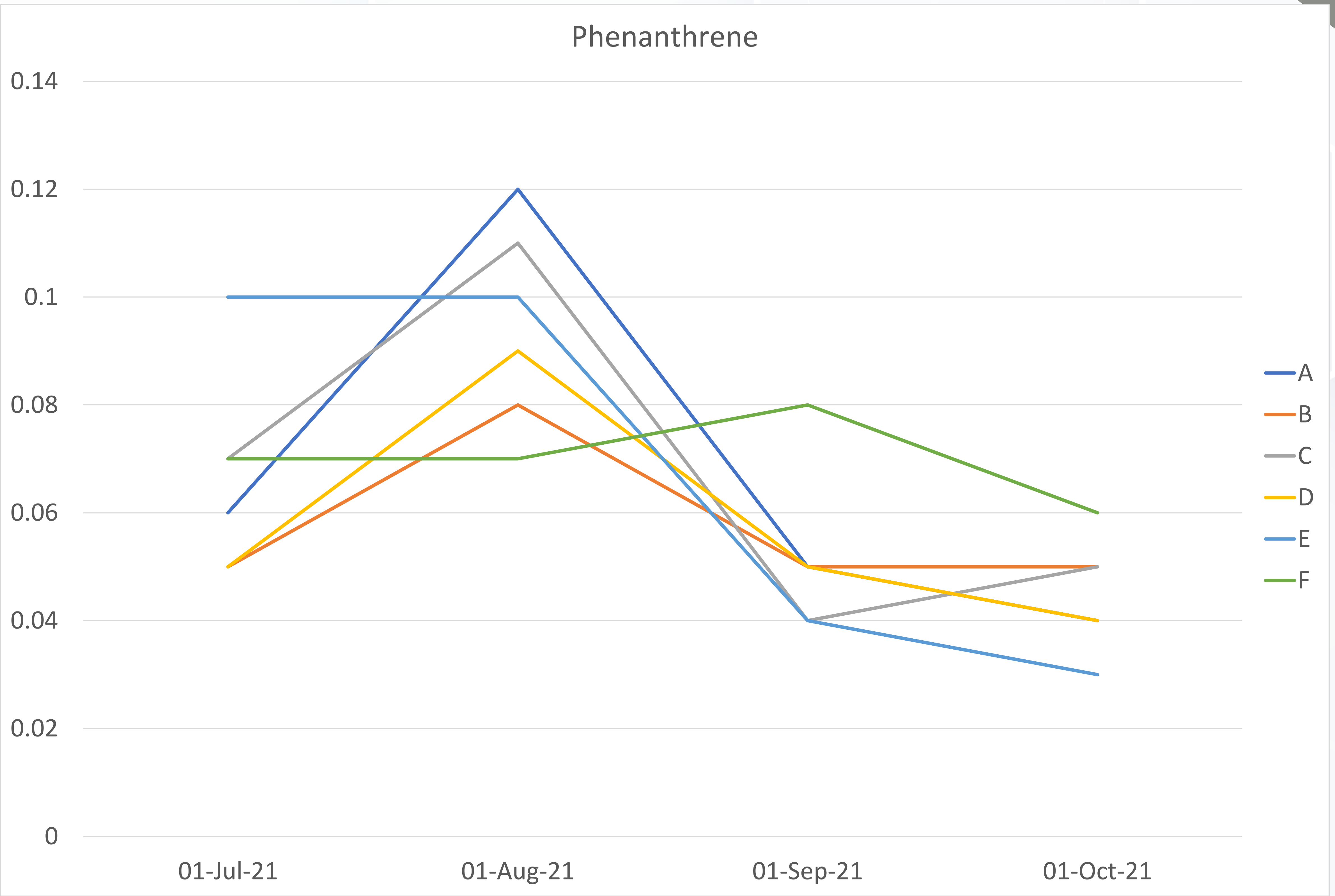
Former Biotreated Site – PHC Analysis



Former Biotreated Site – PAH Analysis





Summary

Literature and background reviews have shown success in mycoremediation benchscale testing

Many contaminants can be considered, depending on species of mushroom and remedial method (ie/ uptake vs. destroy)

Benchscale testing should always be considered prior to immediate applications to ensure soils are suitable

Mycoremediation has been proven to be viable for PAH and heavy end contaminant remediation. Economical feasibility will still need to be considered.

Thank You.

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