

Plant Uptake of Metals and PHCs: Advancing ERA

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Outline

1. Project Background
2. Workplan and Methods
3. Findings
4. Conclusions
5. Future Research Plans



Project Team

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**Alberta Upstream Petroleum
Research Fund (AUPRF)**



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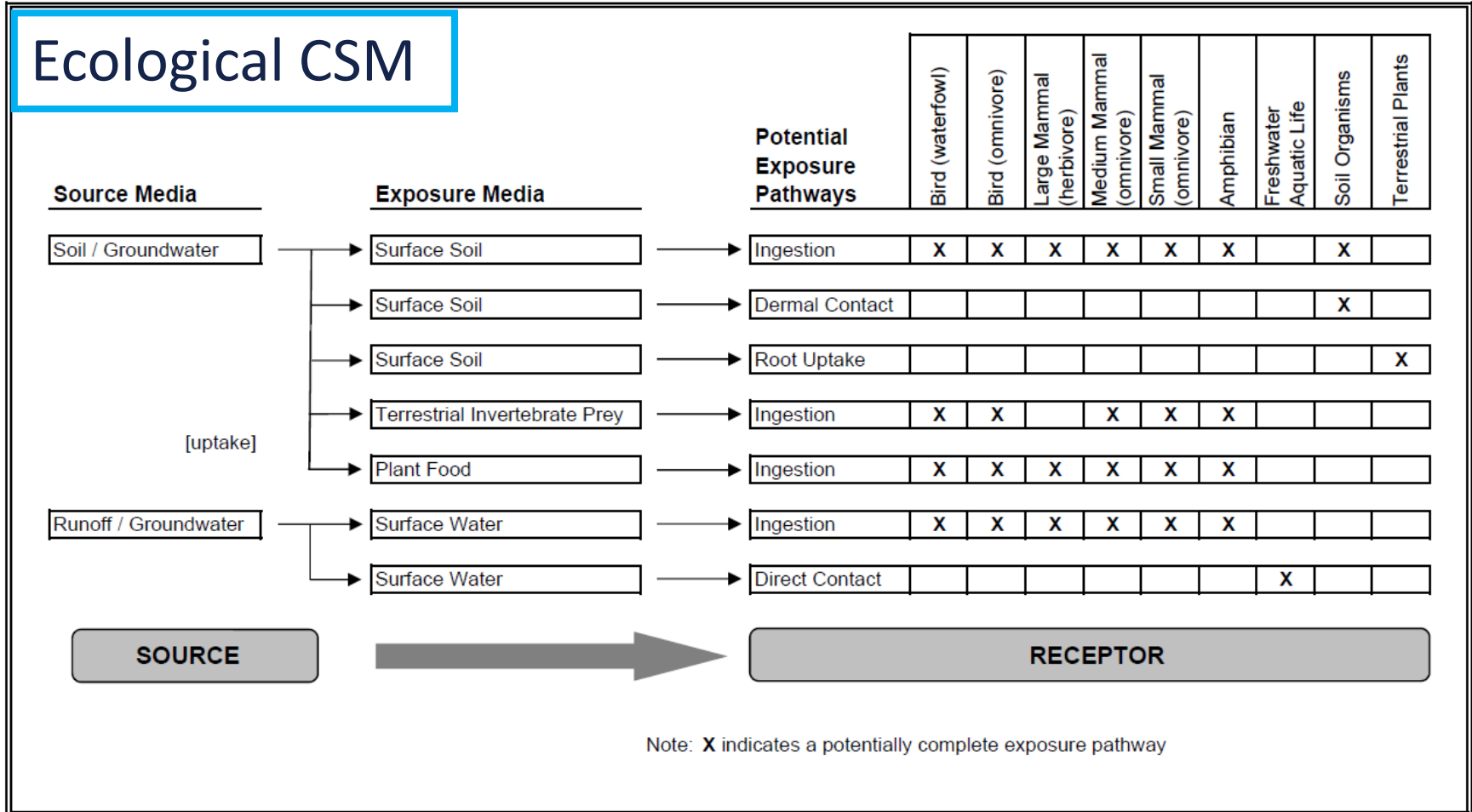
**PETROLEUM
TECHNOLOGY
ALLIANCE
CANADA**

1. Project Background

Why complete this study?

- Was conducting HHERAs for Oil & Gas sites and identified potential risk for F2 associated with the '*consumption of plants*' exposure pathway.
- To complete exposure assessment (dose calculation, mg/kg-day), require concentrations of hydrocarbons in plants.
- Plant concentrations can be measured in laboratory or can use soil-to-plant uptake factors (PUFs).
- What are these factors:
 - $\log(UF_{SP}) = (1.588 - 0.578 \log(K_{ow})) \times 0.2$, or values from literature
 - Conservative guesstimate, 10 or 20%
- A need for additional research to develop more robust PUFs that will allow for more accurate assessments of potential health effects (humans and eco receptors) from exposure to contaminants in plants.

1. Project Background



1. Project Background

Study Objectives

1. Determine the extent to which plants, four species in total, uptake PHCs and trace metals,
2. Establish PUFs (or models) for specific PHC constituents and metals, and
3. Compare calculated PUFs to PUFs obtained from the literature.



2. Work Plan and Methods

Plant Species

Functional Type	Common Name	Species	Range
Grass	Barley	<i>Hordeum vulgare</i>	Peace River Region, Central AB, and Southern/Southeastern AB
Grass	Italian ryegrass	<i>Lolium multiflorum</i>	Peace River Region, Central AB, and Southern AB (irrigation)
Grass	Corn (Maize)	<i>Zea mays</i>	Southern region of AB
Forb	Yarrow	<i>Achillea millefolium</i>	Throughout AB
Legume	Pea plant	<i>Pisum sativum</i>	Peace River Region, Central and Southern AB

- Plant species selection based on:
 - Presence in Alberta
 - Variety of functional types
 - Availability and ease to work with in the laboratory
 - Growth characteristics (e.g., speed of growth, time to flowering)

2. Workplan and Methods

Project Components

1. Hydroponics

- elevated Cu, Ni, Pb, and Cr in nutrient solution
- 9 days exposure/growth

2. Metals in Soil

- elevated Cu, Ni, Pb, and Cr in soil
- short-term (9 days)
- long-term (~7 weeks)

3. Diesel Contaminated Soil

- 9 days exposure/growth



2. Workplan and Methods

Hydroponic Systems – pros and cons

Pros

- Much of the experimental setup can be found outside of scientific supply companies, thus less expensive and more convenient.
- Nutrient media and availability can easily be controlled.
 - nutrient bioavailability changes throughout the soil matrix as nutrients bind to soil particles creating micro-environments within the soil.
- Intact roots and shoots for experimentation.

Cons

- Conditions may be seen as ‘non-physiological’, and plant responses may differ when grown in alternative systems (e.g., soil).

2. Workplan and Methods

Hydroponics

1. Barley, Corn, Italian Rye, and Peas.
2. Grown for 9-days in nutrient solution.
3. Sample types for each plant:
 - spiked solutions (fertilizer + 5 x CCME irrigation guidelines for Cu, Ni, Pb, and Cr)
 - control solutions (only fertilizer)
 - evaporative controls (no plant)
4. Plants sampled on day 9.
5. Analysis with ICP-MS.



2. Workplan and Methods

Soil Metals Uptake – long-term trial

1. Barley, Italian Rye, Corn, and Peas.
2. 5 sampling points (t_0 , 9 days, 2 weeks, 5 weeks, and 7 weeks).
3. Soil spiked with 2 x CCME guideline for Cu, Ni, Pb, and Cr.
4. Samples per plant type:
 - spiked soils/sampling point
 - control/sampling point
 - evaporative controls/sampling point
5. Samples collected and analyzed with ICP-MS.



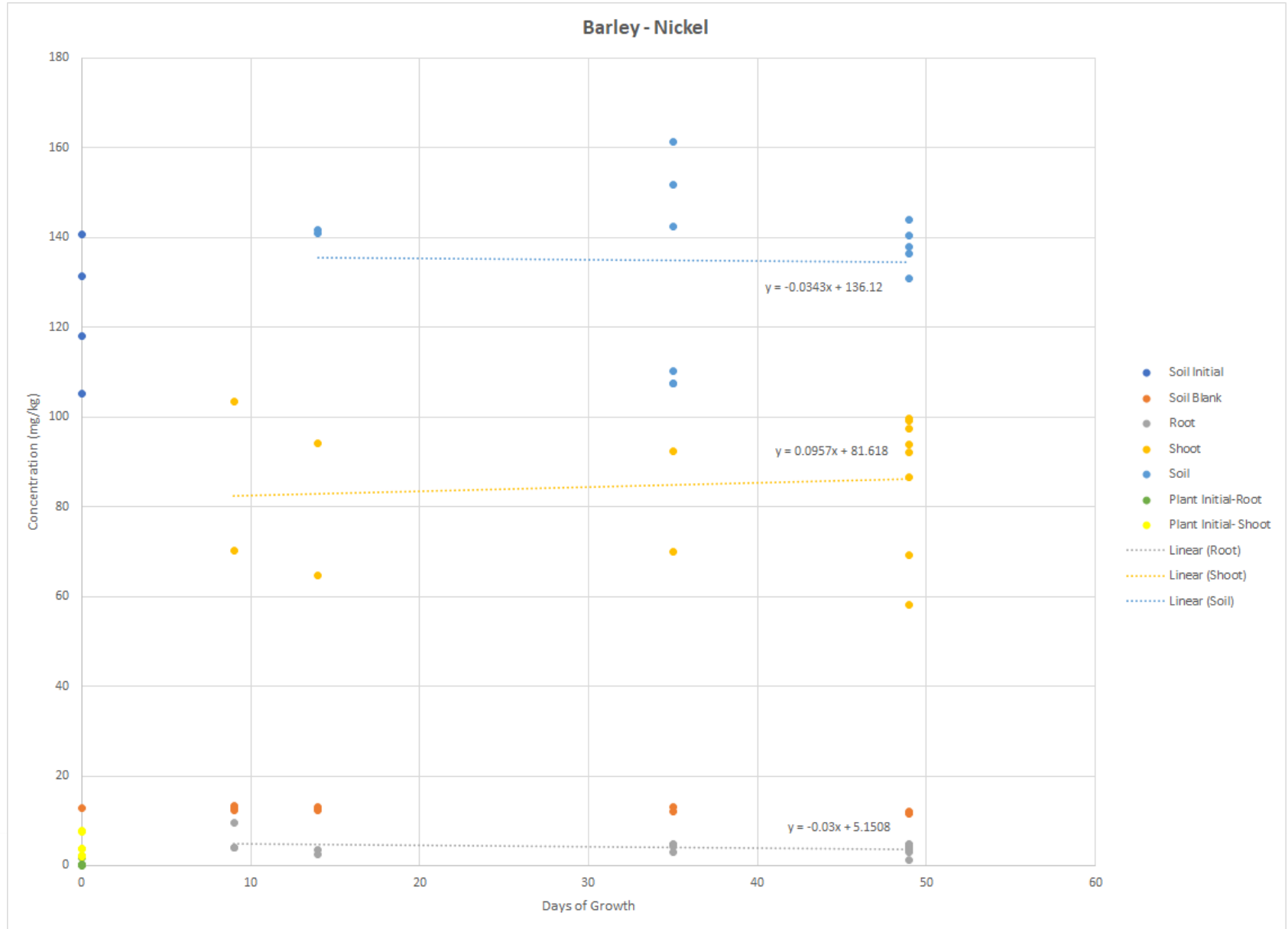
2. Workplan and Methods

PHC Uptake

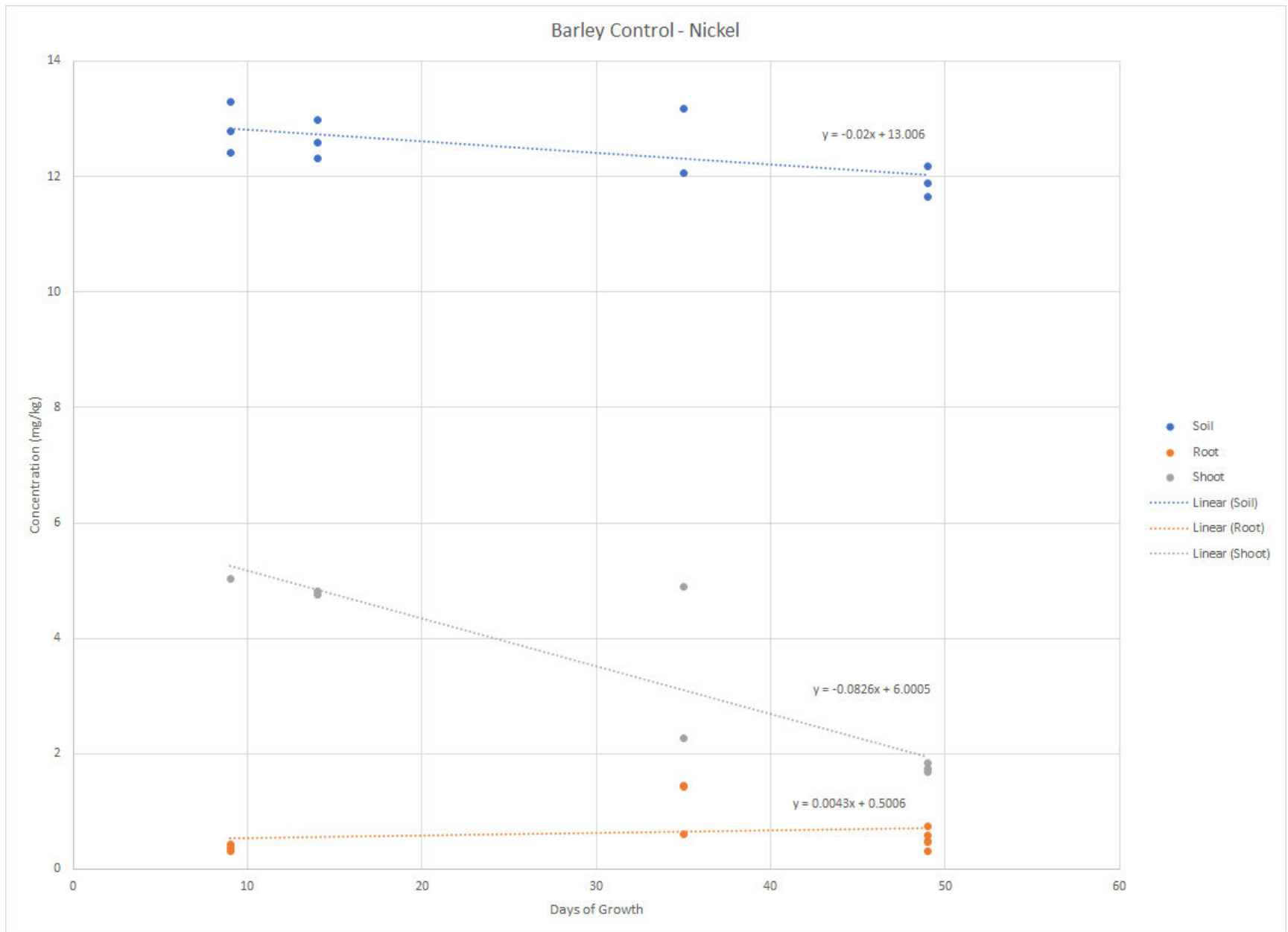
1. Barley, Italian Rye, Corn, Peas, and Yarrow.
2. 10 mg/kg of diesel (mixed with fine perlite then mixed in with soil).
3. Grown for 9 days.
4. Sample types per plant:
 - spiked soils
 - control soils
 - evaporative controls (no plant)
5. Samples extracted, cleaned and analyzed using GCxGC TOF-MS.



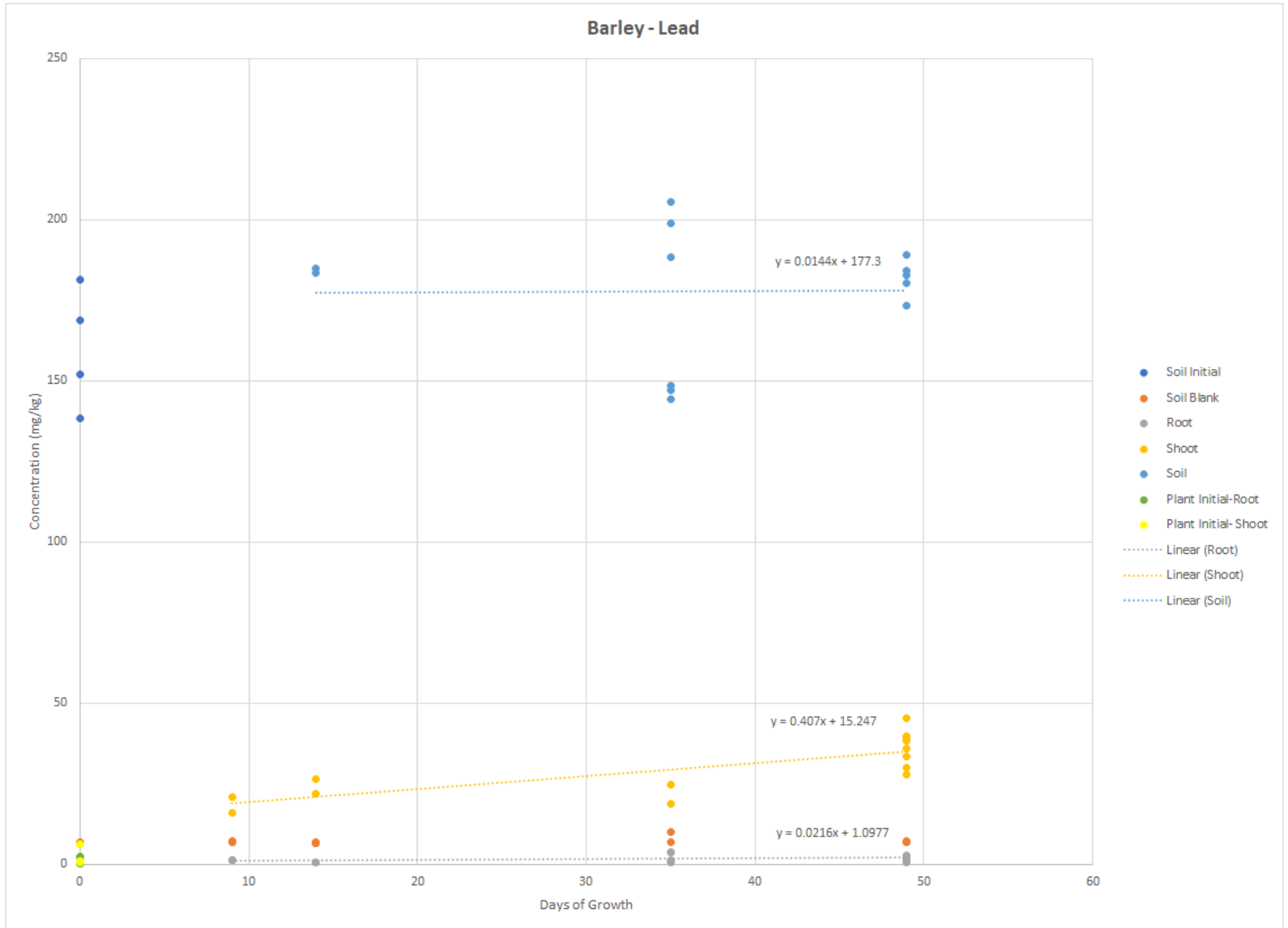
3. Findings - Soil Metals Uptake, Long-term Trial



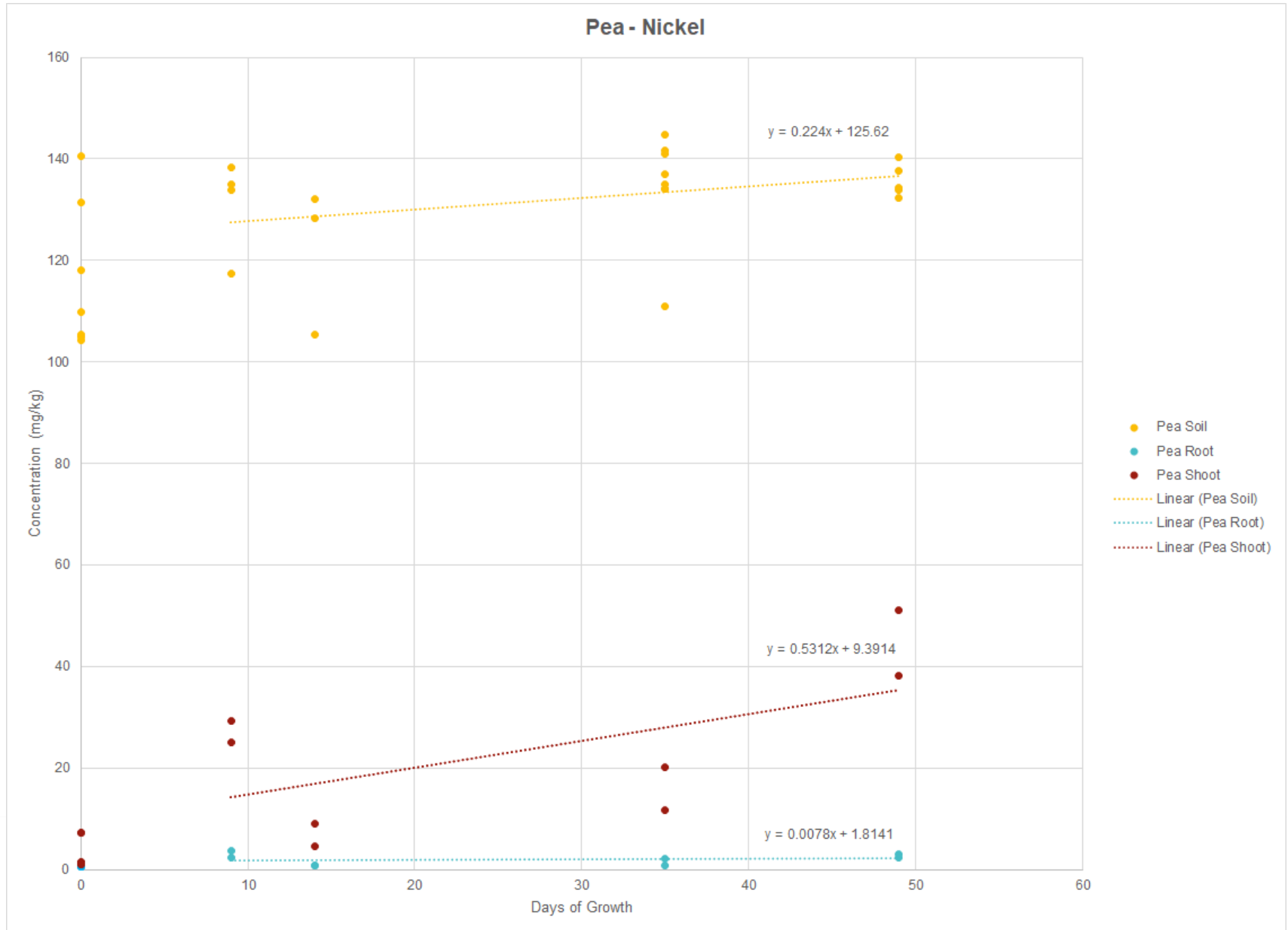
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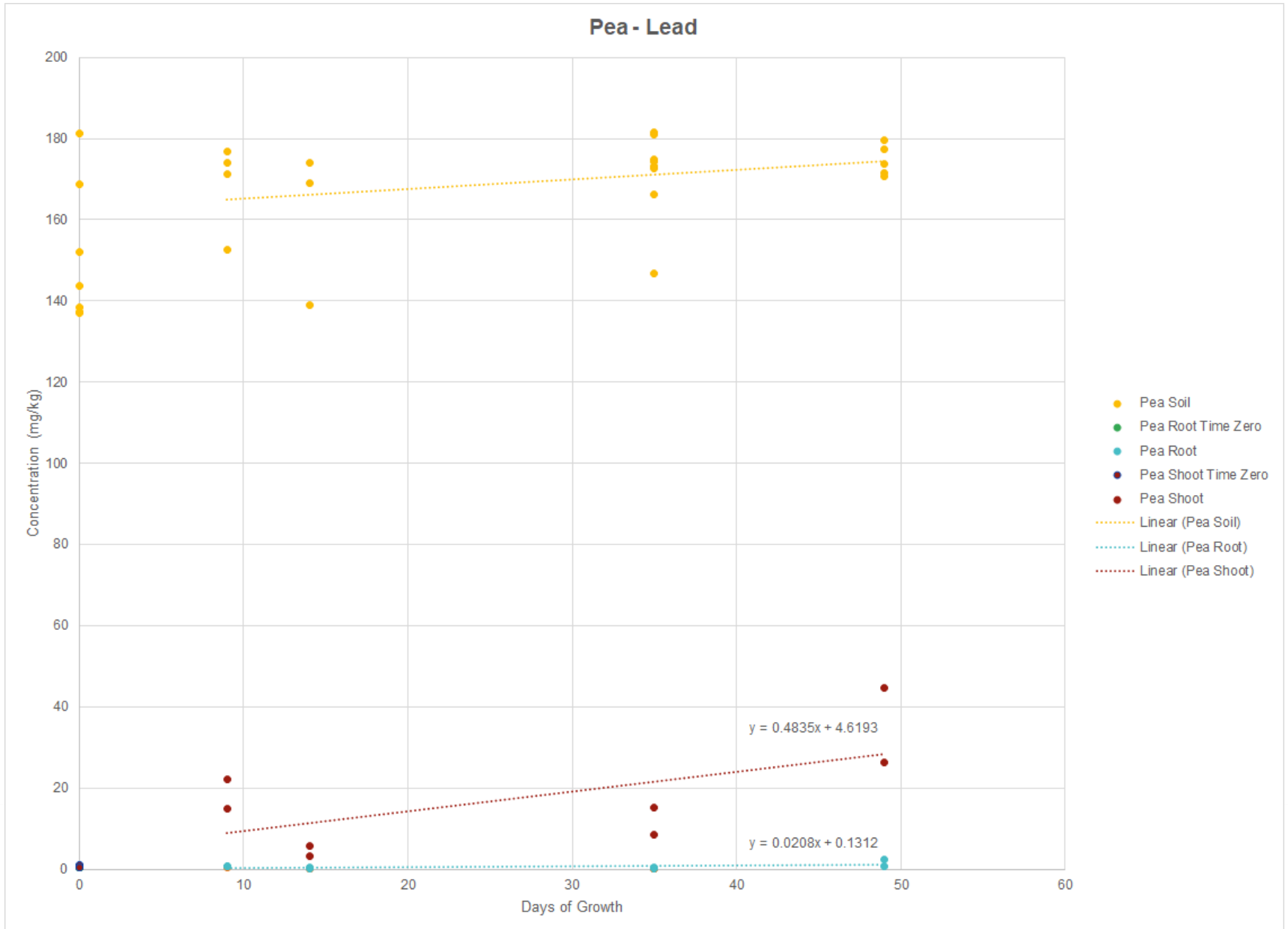
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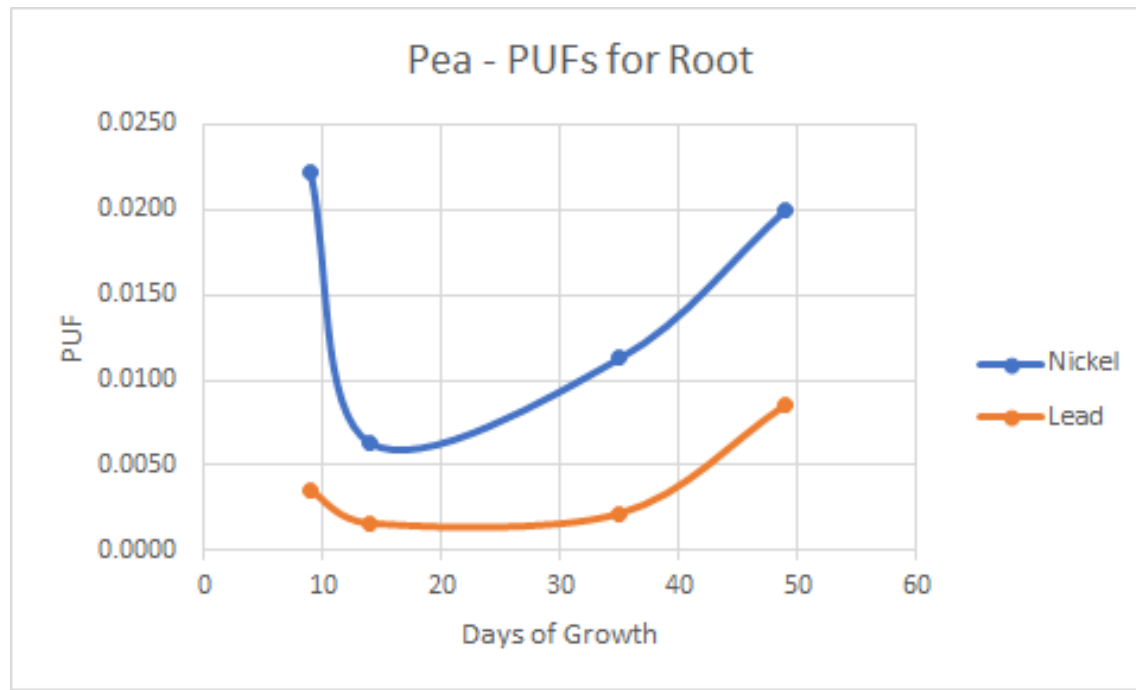
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3. Findings - Soil Metals Uptake, Long-term Trial



3. Findings - PUFs



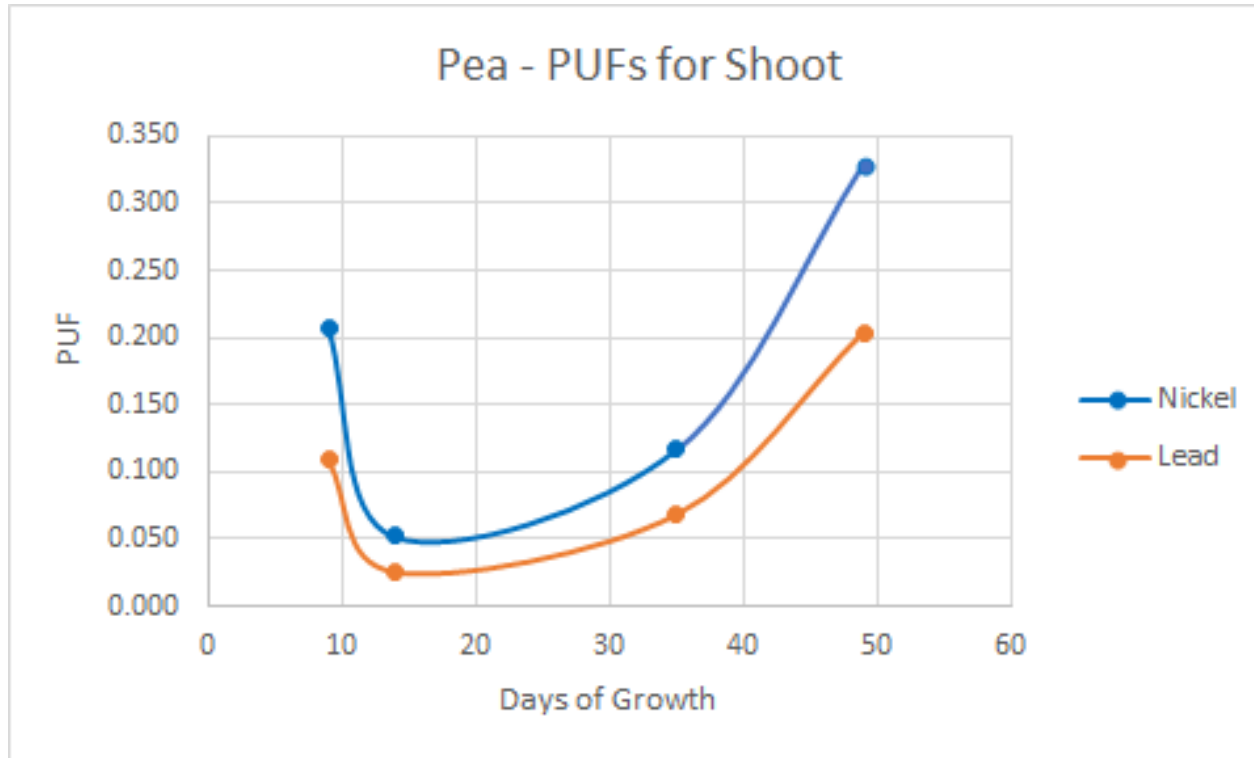
Nickel: 0.006 to 0.028

Chromium: 0.001 to 0.013

Lead: 0.001 to 0.013

Copper: 0.006 to 0.056

3. Findings - PUFs



Nickel: 0.035 to 0.38

Chromium: 0.014 to 0.26

Lead: 0.018 to 0.26

Copper: 0.052 to 0.43

3. Findings - PUFs

Pea, PUFs for shoot vs. Literature PUFs

- 1. Nickel: 0.035 to 0.38
Nickel: 0.015 to 0.06 (RAIS, Baes et al., 1984)
Nickel: 0.1 to 0.2 (guesstimate)

- 2. Lead: 0.018 to 0.26
Lead: 0.011 to 0.045 (RAIS, Baes et al., 1984)
Lead: 0.1 to 0.2 (guesstimate)

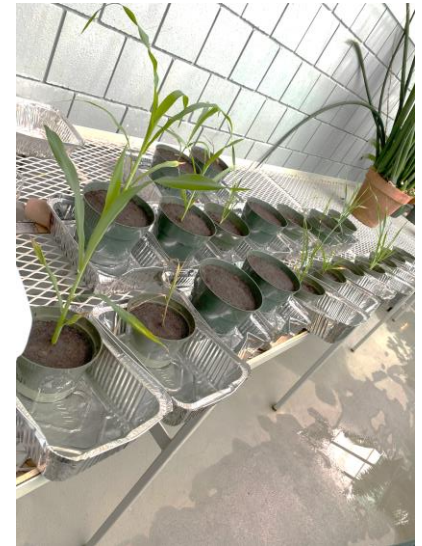


4. Conclusions

- Developing a comprehensive database for PUFs.
 - 2 plant growth methods
 - 4 plant species
 - roots and shoots
 - 5 time points
- A lot of data analysis remains.
- Our PUF values appear to be elevated versus literature values (based on analysis of a small portion of our dataset).

5. Future Research Plans

- Plant uptake studies with additional hydrocarbon doses and parameters (F3?).
- Conduct field studies to evaluate whether laboratory PUFs will correctly determine the concentration of PHCs and metals in plants.
- Evaluate how the newly derived PUFs may (or may have) influenced the risk assessment process.



Questions?

Thank You!

ADBE

Phytodegradation

Breakdown or transformation by enzymes in tissue

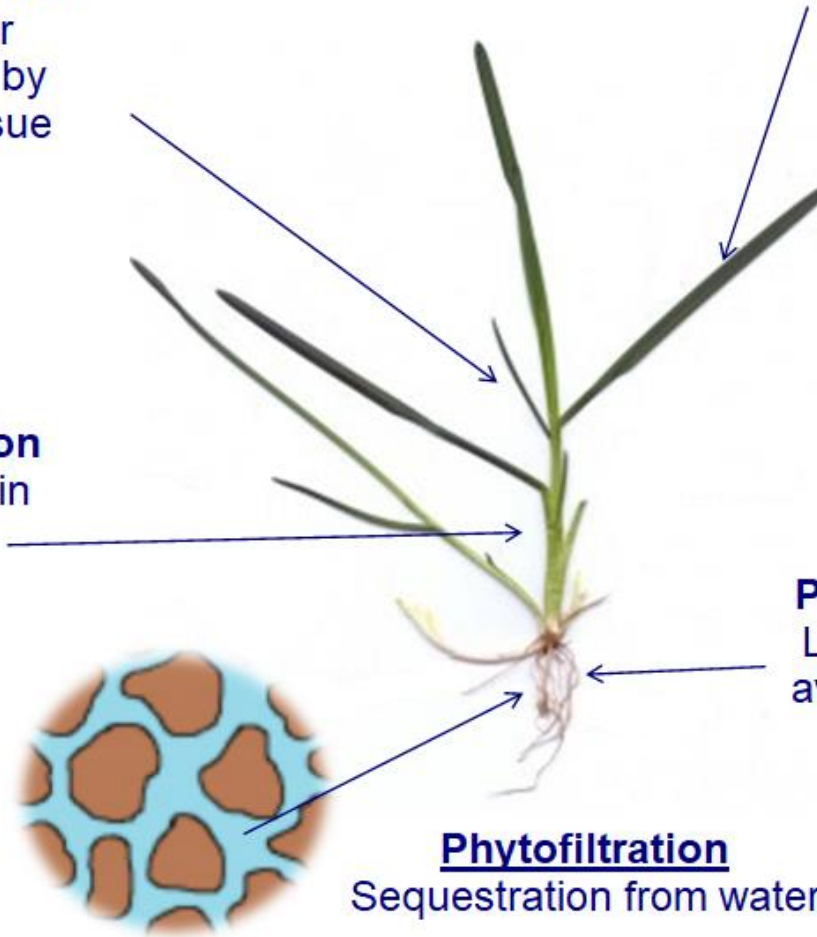
Phytovolatilization
Converts to volatile form, releases to atmosphere through leaf surface

Phytoextraction

Accumulation in shoots

Phytostabilization

Limits mobility and availability in soil by roots



Phytofiltration
Sequestration from water

