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**WorleyParsons Komex**

resources & energy



# Bioremediation and Characterisation of Oilfield Waste Containing Elevated Concentrations of Weathered F3 Hydrocarbons

**Brooke Bennett, Environmental Scientist**

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when experience counts



- ▶ Introduction
- ▶ Objectives
- ▶ Test soil, compost, mulch
- ▶ First phase of project – bench scale
- ▶ Plant toxicity tests – preliminary results
- ▶ PHC F3 – preliminary results
- ▶ Summary
- ▶ Acknowledgments



- ▶ Hydrocarbon bioremediation project initiated by KC Environmental Group.
- ▶ Previous study found a decrease in PHC F3, but only captured data at beginning and end of trial.
- ▶ Collaborative project between WorleyParsons Komex, Cleanit Greenit Composting Systems Inc., and Geotechnical Engineering group at the University of Alberta.



- ▶ Bench scale and pilot scale components, with same objectives.
- 1. Determine effectiveness of mature compost and/or bark mulch as amendments for bioremediation of weathered PHCs.
- 2. Determine toxicity of soil/compost mixture, toxicity of weathered PHCs.



- ▶ Soil from flare pit plume, Swan Hills, AB
- ▶ Clay till, saturated, subsoil
- ▶ Collected from ~1.2 m below ground surface

Parameter	Average	Soil Quality Guideline
PHC F3	4,260 mg/kg	800/3,500 mg/kg
pH	5.67	6 – 8.5
Arsenic	31.4 mg/kg	12 mg/kg



## ▶ Compost

- Sump, food, yard, wood waste
- Sewage, industrial sludges
- Label pulp (from beer bottles)
- Kitchen grease

## ▶ Mulch

- from Drayton Valley

Parameter	Compost	Mulch	Soil Quality Guideline
PHC F3	1,659 mg/kg	2,223 mg/kg	800/3,500 mg/kg
pH	7.42	6.09	6 – 8.5



**Mulch**

**Compost**





- ▶ Barrels with 4 treatments: soil, compost, mulch, (nitrogen)
- ▶ Bench scale trial conducted for 6 months
- ▶ Room heated, barrels kept at ~30% moisture content
- ▶ Material turned weekly with auger





### ▶ Plant Emergence and Plant Growth Tests

- Environment Canada's Biological Test Method (2005) protocol
- Tests performed by Stantec Consulting Ltd. in Guelph, ON
- 5 test species: barely, northern wheatgrass, red clover, alfalfa, and red fescue
- Reference Soil: background subsoil amended with 25% compost
- Impacted Soil: test soil amended with 25% compost
- Impacted Soil tested at 100% with no dilutions



- ▶ **Seedling Emergence**
  - Significant difference ( $p < 0.05$ ) between Reference Soil (RS) and Impacted Soil (IS)

<b>Test Species</b>	<b>Significant Difference in Emergence (<math>p &lt; 0.05</math>)</b>
Barley	No
Red Clover	No
Alfalfa	Yes
Northern Wheatgrass	Yes
Red Fescue	Yes



- ▶ Plant growth endpoints (6) measured for the five species:
  - Shoot length, shoot wet mass, shoot dry mass
  - Root length, root wet mass, root dry mass



- ▶ Significant difference in measured endpoints between the RS and IS ( $p < 0.05$ )

Endpoint	Alfalfa	Barley	*N.Wheatgr.	Red Clover	Red Fescue
Shoot length	Yes	No	Yes	Yes	No
Shoot wet mass	Yes	Yes	Yes	Yes	Yes
Shoot dry mass	Yes	No	Yes	Yes	Yes
Root length	Yes	Yes	Yes	Yes	Yes
Root wet mass	Yes	Yes	Yes	Yes	Yes
Root dry mass	Yes	Yes	Yes	Yes	Yes

\*Northern Wheatgrass



- ▶ Summary of growth endpoint results:
  - 30 endpoints measured in total
  - 3 were not significantly different ( $p < 0.05$ ) between the RS and the IS
  - all other measured endpoints were significantly different



▶ Overall trends

- Greatest difference in measured endpoint between RS and IS:
  - Root length
- Even though significant difference was shown for most endpoints, similar results for RS and IS for some species:
  - e.g., Shoot wet mass – barley, red fescue, northern wheatgrass
  - e.g., Root wet mass – red fescue, northern wheatgrass
- Red fescue had 4 of the lowest measured endpoints.





▶ Overall trends

- RS shoot length for Northern Wheatgrass less than half in Artificial Soil (AS)
- RS root length for Barley ~1.6 times less than in AS



- ▶ ANOVA results for concentrations of PHC F3 for months 1 to 3 of bench scale project:
  - Significant difference between treatments per month for concentration of PHC F3 ( $p < 0.05$ )
  - No significant difference between treatments overall at end of month 3 ( $p < 0.1$ )



1. Plant emergence test: 3 of 5 species with significant difference between RS and IS.
  - ▶ Red fescue with greatest difference between RS and IS.
2. Of 30 plant growth endpoints, 27 showed significant difference between RS and IS.
  - ▶ Similar results for RS and IS for several endpoints.
3. Cannot conclude if toxicity is due to PHCs or arsenic at this time.
4. No significant difference between treatments at end of month 3 of bench scale project.



- ▶ Toxicity testing at the end of bench scale phase to determine if toxicity changed over time.
- ▶ Further toxicity tests for arsenic and PHC F3 separately.
- ▶ Tests to be conducted at beginning and end of pilot scale (biopile).



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