CREATING AND DELIVERING BETTER SOLUTIONS

Toxicity of Invert Drilling Muds Composted with Wood/Bark Chips

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EBA ENGINEERING CONSULTANTS LTD.

Outline

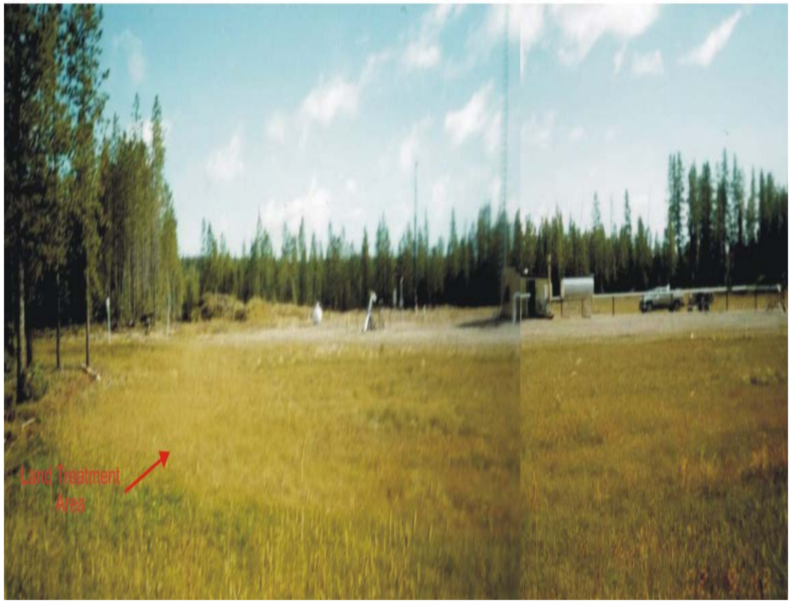
- Background on composted invert drilling mud (CIDM)
- Ecotoxicity study – material tested, tests and species used
- Results of the ecotoxicity study
- Comparison of results to other EBA composting studies
- Summary

Stakeholders &Team

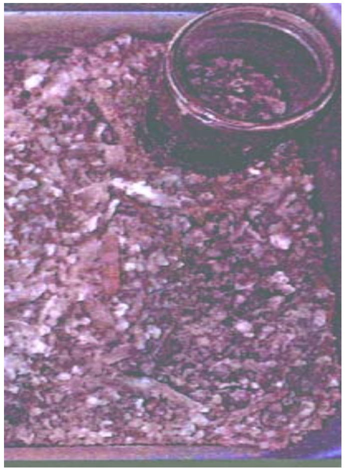
- ConocoPhillips Canada
- Stantec Consulting Ltd. (formerly ESG)
- HydroQual Laboratories
- Alberta Energy and Utilities Board
- Alberta Environment
- Alberta Sustainable Resource Development
- Olds Composting Technology Centre
- EBA Team Members

Background

Since the early to mid 1990s various companies have composted invert (diesel) drilling muds with wood chips/bark chips in the green (forestry) zone as a method of drilling mud treatment



Background



- EBA monitored 22 third-party sites in 2002
- Some were biopiles; some land treatment areas (LTAs)
- Active treatment started between1995 and 1999
- Some LTAs were seeded with various success
- Composted materials had hydrocarbon odour and staining and were very moist
- Materials exceeded AENV guidelines for PHCs and sometimes barium
- Other salts and metals met guidelines

Background

- Most sites are within areas that have forestry production/wildlife as end land use
- Receptors include plants, soil invertebrates by soil contact, and wildlife by ingestion
- Stakeholder meetings were held for their input

"Will this material have an adverse effect on receptors or decrease land capability for reforestation?"

Soil Ecotoxicity

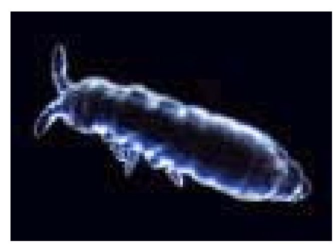
Representative bulk samples collected for ecotoxicity testing, including:

- 4 field samples:
  - Biopile with high PHC concentrations (F2=12000, F3=13000)
  - Biopile with typical PHC concentrations (F3=2780)
  - LTA with some staining, PHC concentrations (F3=3600)
  - LTA with no staining, PHC concentrations (F2=2200; F3=6600)
- 2 "stable" biotreated lab samples (T=12 mo)
  - Biopile with treated PHC concentrations (F2=2500, F3=8100)
  - Biopile with treated PHC concentrations (F2=1000+/-383, F3=5459+/-1631, mean +/- 1 SD for 11 replicates)
- 4 controls: topsoil, subsoil, compost, and lab reference

Soil Ecotoxicity

Stantec (formerly ESG) did acute and chronic testing using Environment Canada procedures for:

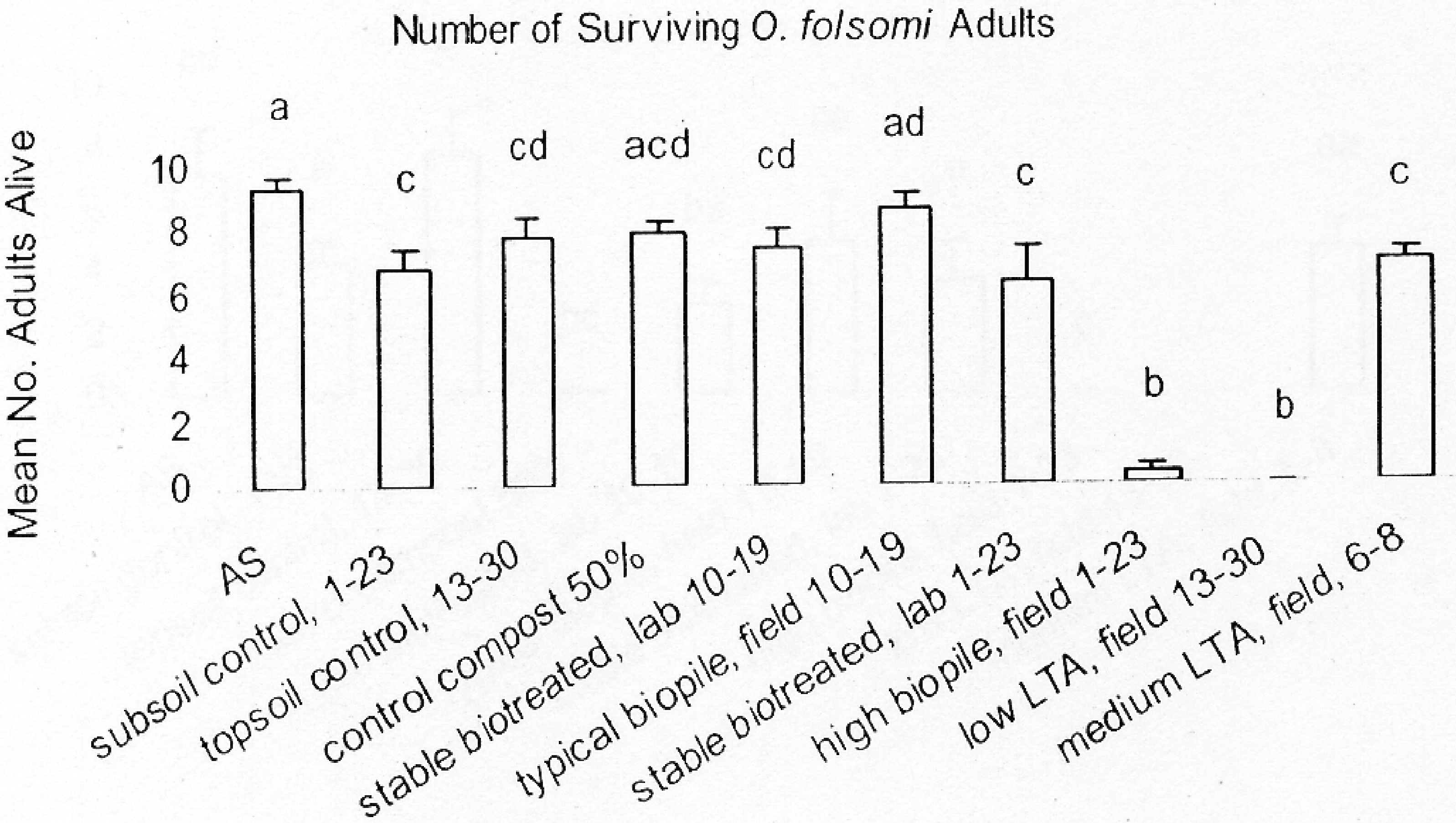
- 2 invertebrates: springtail and earthworm
- 3 plant species: barley, northern wheatgrass, American vetch



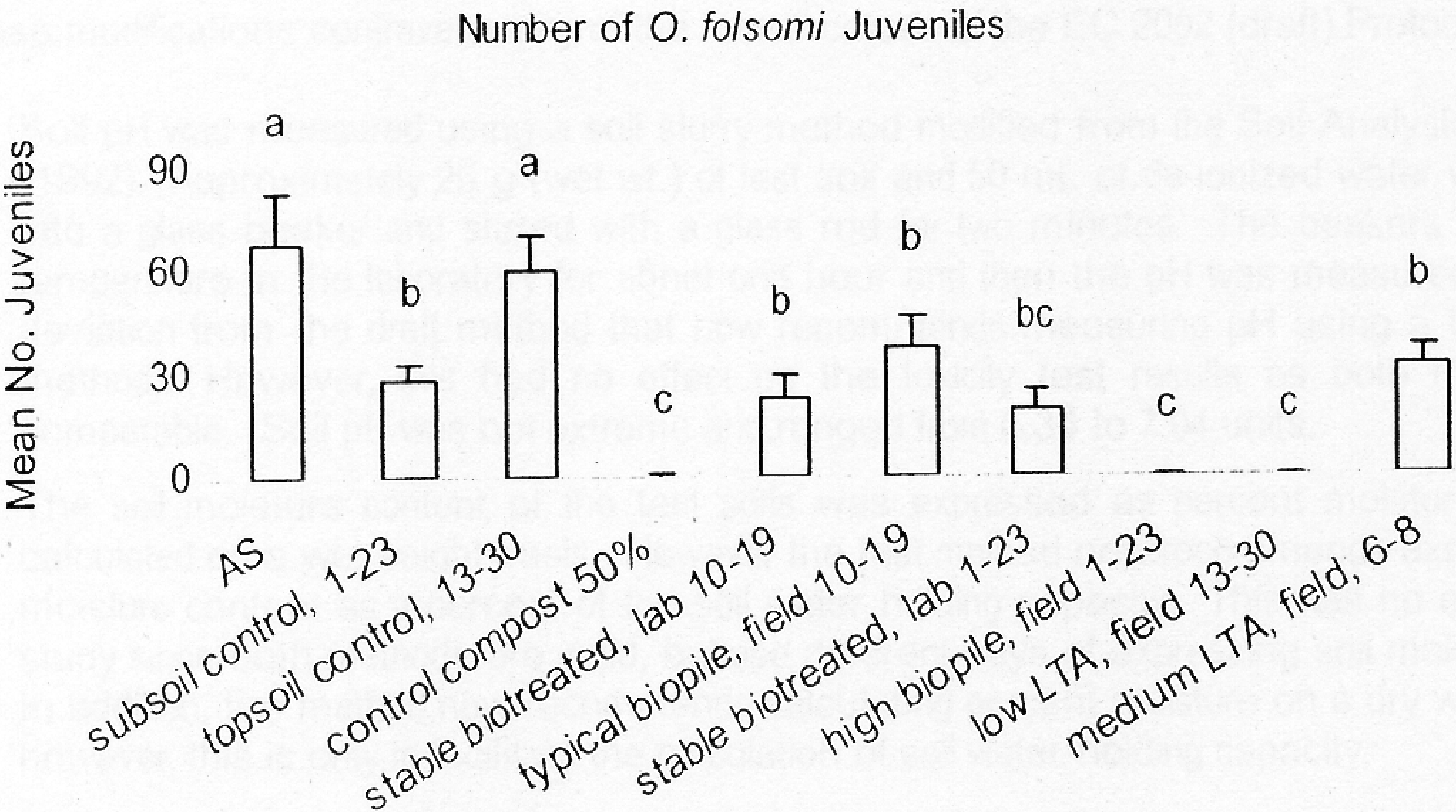
Example – Springtail Chronic Test

Onychiurus folsomi Chronic (35-d) Screening Toxicity Test with Biotreated PHC-contaminated Soil

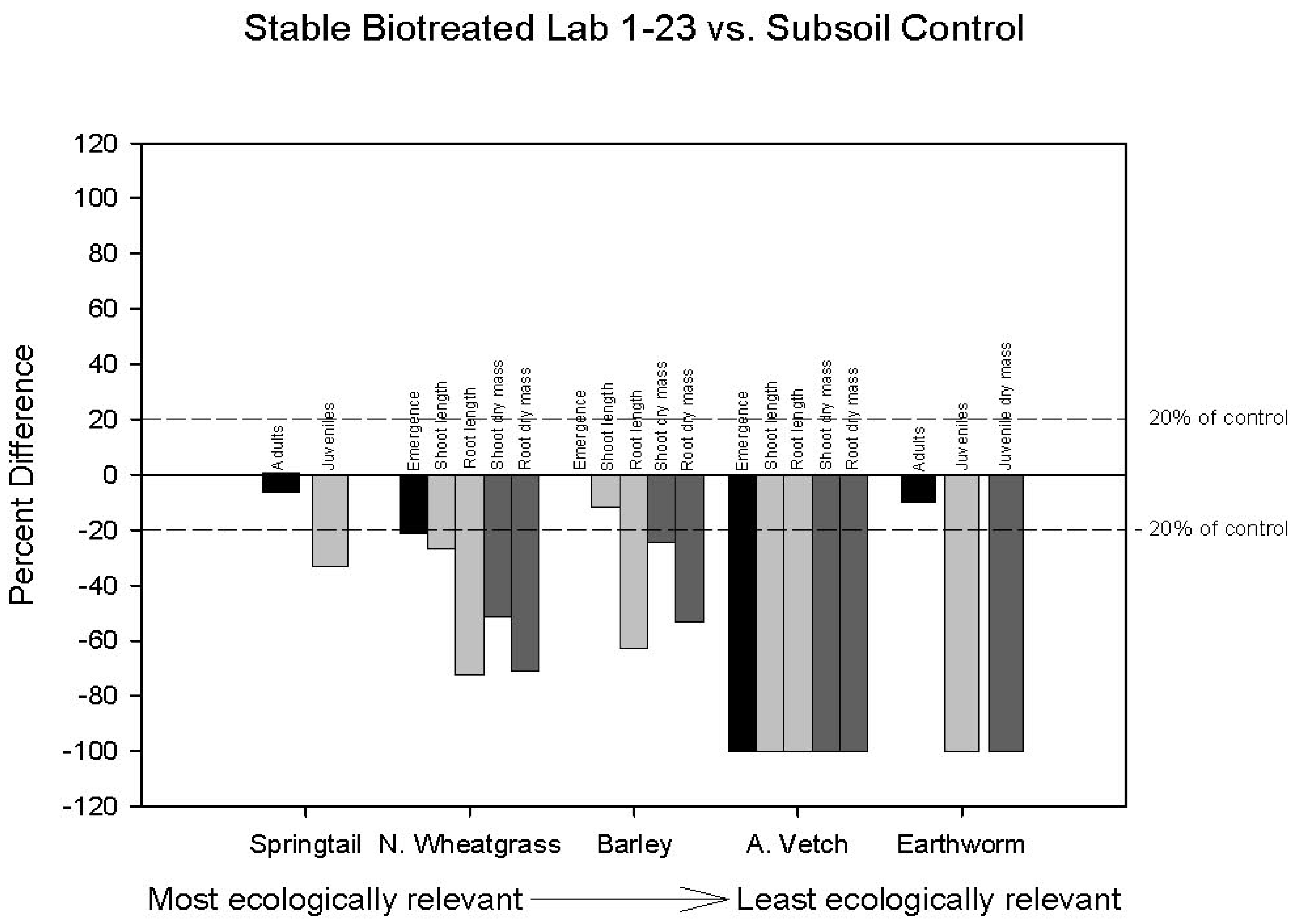
Test Conditions and Procedures	
Test Protocol:	Aquaterra Environmental (1998)
Measurement endpoint(s):	Number of surviving adult collembolan, number of juveniles
Soil mass/test unit:	30 g wet mass
No. organisms per test unit:	10
No. replicate test units/treatment:	10 (with organisms), 1(for final soil chemistry)



Adult 35-d survival of *Onychiurus folsomi*. Columns indicate treatment means. Bars above the columns represent one standard error. Columns with the same letter indicate no significant differences among treatment means at $P \geq 0.05$



: 35-d *Onychiurus folsomi* juvenile production. Columns indicate treatment means. Bars above the columns represent one standard error. Columns with the same letter indicate no significant differences among treatment means at $P \geq 0.05$

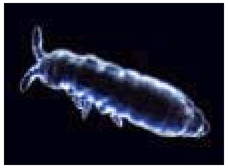


Stable Biotreated Lab 1-23 vs. Subsoil Control
Percent Difference
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
20% of control
- 20% of control
Adults
Juveniles
Emergence
Shoot length
Root length
Shoot dry mass
Root dry mass
Emergence
Shoot length
Root length
Shoot dry mass
Root dry mass
Emergence
Shoot length
Root length
Shoot dry mass
Root dry mass
Adults
Juveniles
Juvenile dry mass
Springtail
N. Wheatgrass
Barley
A. Vetch
Earthworm
Most ecologically relevant
Least ecologically relevant

Soil Ecotoxicity

- Acute tests often did not show any effect
- Chronic tests – there were differences: earthworm and springtails survived but reproduction was affected; plant growth was affected
- Most toxic was the composted subsoil with wood/bark chips (a control!)
- CIDM had more toxicity than control topsoil and subsoil
- No obvious decrease in toxicity from field to stable biotreated samples






Study Limitations

- Could not separate the degree of toxicity from wood/bark chips, the PHCs or other factors such as salinity or ammonia

The Concern with Wood/Bark Chips

- Large chips are slower to degrade
- Type of tree and part of tree affects toxicity
- Mulching affect is first physical and chemical, then nutrient deficiency
- Chemical toxicity comes from resins, lignins, tanins, and phenols
- Leachate from wood/bark chips can be toxic*

*Alberta Environment. 2002. Assessment of Log Yard Runoff in Alberta

How did the Project Proceed?

Other remedial alternatives were evaluated with stakeholders and client, including:

- Thermal Desorption
- Leaching or Soil Washing
- Landfilling
- Addition of Humic Acids or Activated Charcoal
- Enhanced phytoremediation

How did the Project Proceed?

- Client made decision to manage their liability by landfilling most of the CIDM sites
- A pilot using Dr. Greenberg’s, enhanced phytoremediation technology is proceeding on one active well site

"How do these results compare with composting studies done with other organic matter amendments and types of hydrocarbons by EBA?

Two other studies done on composting with softwood chips or sawdust: Swan Hills and Turner Valley

Swan Hills

- PHC source was flare pit (burnt crude oil), some salts and hydrophobicity
- Organic amendments were manure and sawdust
- Composted up to 11 months, final C11-C60+ hydrocarbons was 42,000 mg/kg

Swan Hills

Battery of ecotoxicity tests:

- Lettuce seed emergence, germination and root elongation (acute test)
- earthworm survival, reproduction not measured
- SOS chromotest
- soil respiration
- bacterial luminescence
- total heterotrophic bacteria, hydrocarbon degrading bacteria

Plant grow-out (timothy and barley)

Cress test

Conclusions:

The compost material was as good or better than the control

Swan Hills Plant Grow Out

Barley

A-Compost, T=11 mo.

E-Control subsoil with sawdust & manure

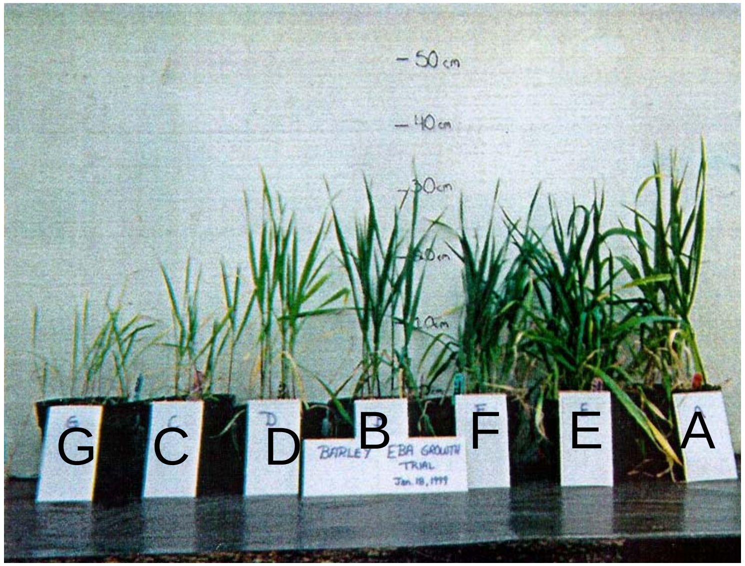
F-Compost, leached

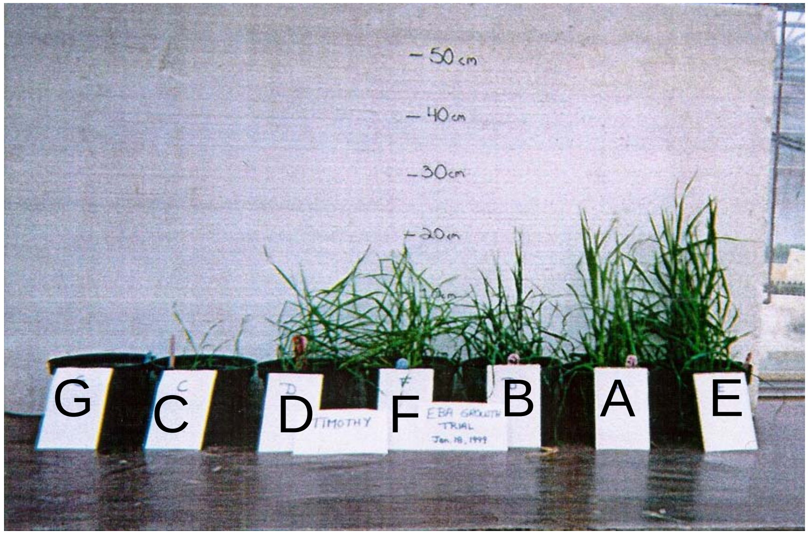
B-Control subsoil

D-Compost, T=0 mo.

C-Flare pit soil

G-Flare pit, leached





Timothy

Turner Valley

Source: weathered crude oil; salts and metals meet guidelines

Organic matter compost trials:

- Contaminated soil
- Woodshavings
- Manure/Straw
- Straw
- Compost control
- Control topsoil and subsoil

Turner Valley

Battery of ecotoxicity tests similar to Swan Hills

- no plant grow-outs
- Acute plant tests with lettuce
- worm avoidance not worm survival
- some low organic matter mixtures

Conclusions:

- none of the composted materials were very toxic
- source > woodshavings > manure/straw > straw > manure/straw control > control topsoil and subsoil

Summary

- CIDM affects the reproduction of earthworms and springtails, and plant growth
- Wood/barks chips themselves can be ecotoxic
- Other compost studies with finely ground sawdust and no bark chips have less ecotoxicity

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