

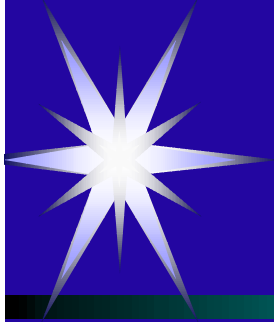
***Effect of Compost Age and Operating  
Temperature on Biodegradation of Diesel Fuel  
Contaminated Soil***

***Rafik Hesnawi<sup>1</sup> & Daryl McCartney<sup>2</sup>***

***<sup>1</sup>Department of Civil & Geological Engineering, University Of Manitoba***

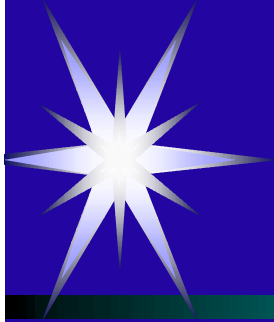
***<sup>2</sup>Department of Civil & Environmental Engineering, University Of Alberta***

**Email: [umhesnaw@cc.umanitoba.ca](mailto:umhesnaw@cc.umanitoba.ca) (presenter & author for all correspondence)**



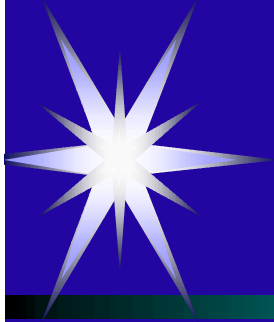
# Presentation Outline

- **Background**
- **Research Objective**
- **Material & Methods**
- **Results and Discussion**
- **Summary & Conclusions**



# Potential of Composting Bioremediation

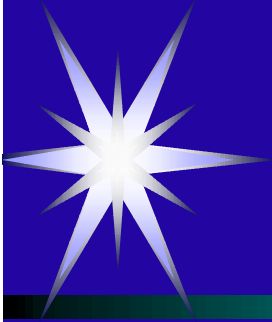
- **Elevated (thermophilic) temperatures:**
  - **Increase microorganisms diversity;**
  - **increase rate of desorption;**
  - **increase rate of hydrocarbon biodegradation.**
- **Addition of organic material should increase the size of non-extractable fraction;**
- **Overall, composting systems decrease mobility of hydrocarbons in the environment.**



# Composting of Hydrocarbons

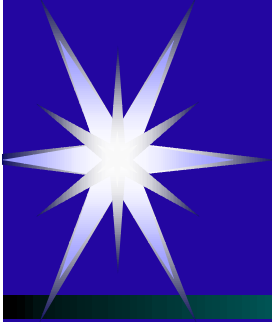
## Effective removal of hydrocarbons:

- 70-90% removal of PAH such as pyrene & chrysene in 175 days with addition of mature compost (Wischmann and Steinhart, '97).
- 60% and 54% removal of aliphatics and aromatics in 105 days with addition of fresh compost ( Beaudin et al. '96).
- 23% of the  $^{14}\text{C}$ -labeled anthracene was mineralized with addition of mature compost (Kastner et al. '95).

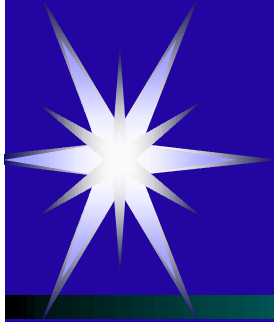


## **Temperature effect hydrocarbons removal:**

- **Similar removals (95%) of aliphatic (octadecane) and aromatic (phenanthrene) at 35°C and 50°C (Hogan et al. 1989).**
- **70% of petroleum hydrocarbons removed at 50°C while 56% at 23°C (Beaudin et al. 1999).**
- **44% of  $^{14}\text{C}$  benzene was mineralized at 50°C while 1% at 37°C (Semple et al. 1998).**



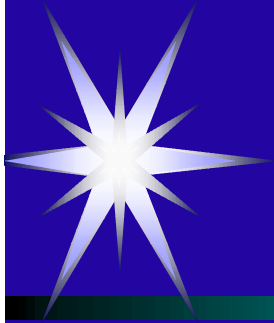
- **25% of hexadecane and 1% pyrene were mineralized at 55°C while more than 45% at 30°C ( Haderlein et al. 1999).**



# **Research Activities at U Of M**

## **Research Objective**

**To compare the effects of operating temperature and feedstock age on biodegradation and adsorption of radiolabelled phenanthrene and extractable diesel range organics.**



# Material & Methods

## Material

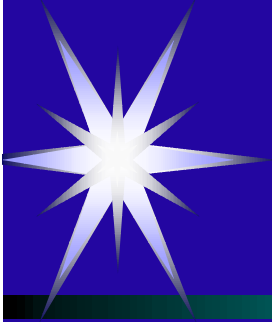
### Soil (Sand)

<b>MC (wb)</b>	<b>50% of MHC</b>
<b>Diesel Fuel</b>	<b>20,000 mg diesel/ kg dry soil</b>
<b><sup>14</sup>C-Phenanthrene</b>	<b>0.15 <math>\mu</math>ci/g diesel fuel</b>

### Compost (Fresh Compost & Finished Compost)

<b>Biosolids</b>	<b>4.59 kg (wb)</b>
<b>Leaves</b>	<b>1.14 kg (wb)</b>
<b>Woodshavings</b>	<b>0.77 kg (wb)</b>





## **Soil : Compost Mixtures**

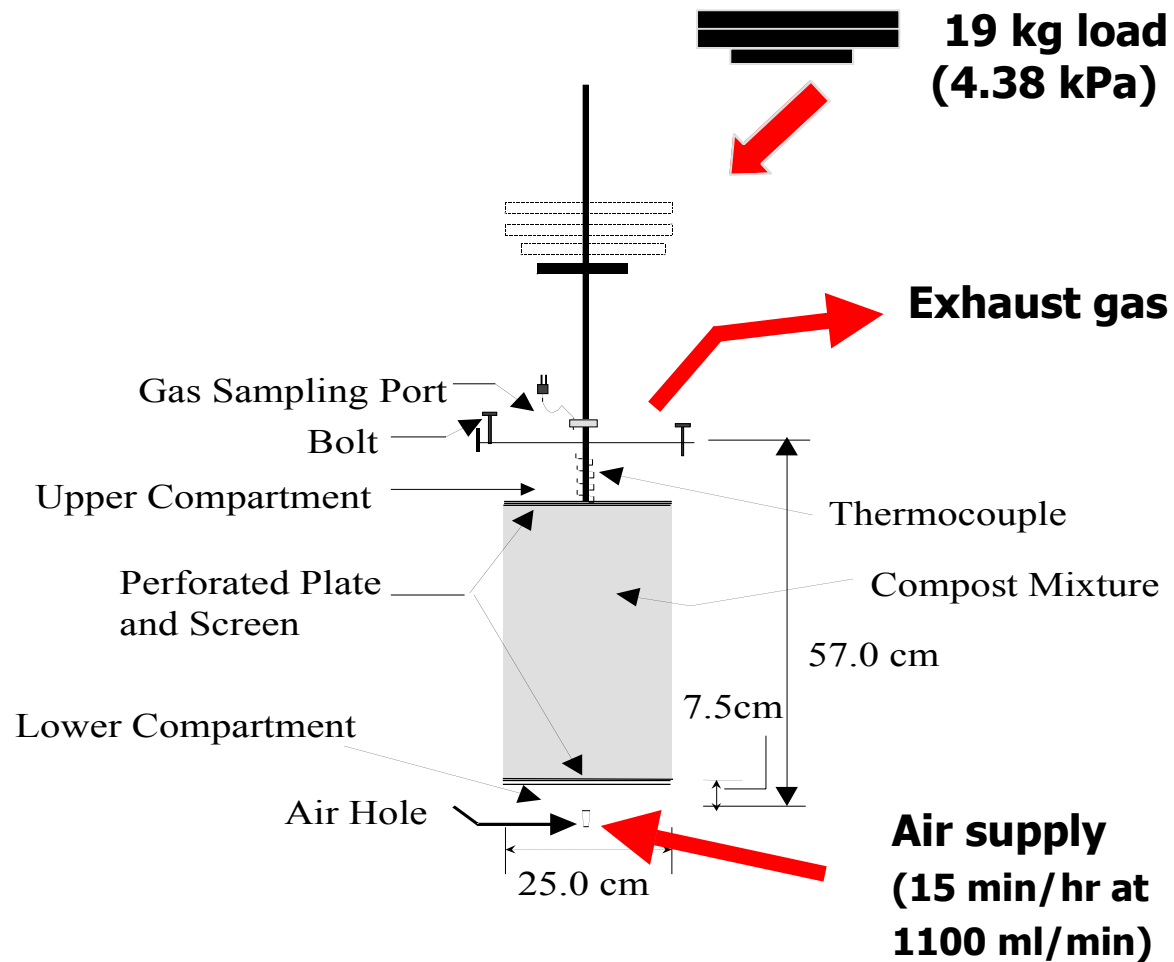
- **Fresh Compost Mixtures**

<b>Compost Feedstock Content:</b>	<b>6.5 kg (wb)</b>
<b>Sand Load:</b>	<b>4.33 kg (wb)</b>
<b>Moisture Content:</b>	<b>40% (wb)</b>

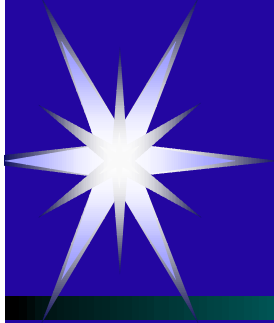
- **Finished Compost Mixtures**

<b>Compost Feedstock Content:</b>	<b>6.5 kg (wb)</b>
<b>Sand Load:</b>	<b>4.33 kg (wb)</b>
<b>Moisture Content:</b>	<b>40% (wb)</b>

# Reactor Apparatus



- A total of 10 reactors
- Run for 126 days



## Approaches Employed

### Treatments Replicates

- **Cont. Soil & Finished Compost**
- **Cont. Soil & Finished Compost**
- **Cont. Soil & Fresh Compost**

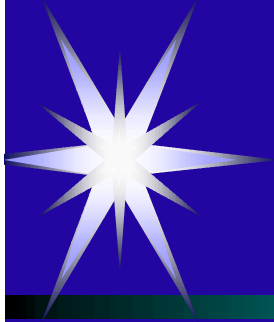
### Temperature

- Meso**                      **2**
- Thermo**                    **2**
- Thermo**                    **2**

### Controls

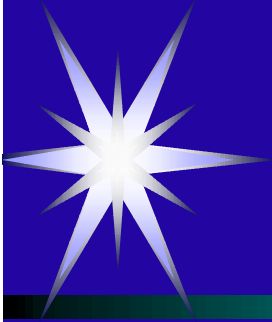
- **Cont. Soil with no Compost**
- **Non-cont. Soil & Fresh Compost**

- Thermo**                    **2**
- Thermo**                    **2**



# Sampling and Analysis

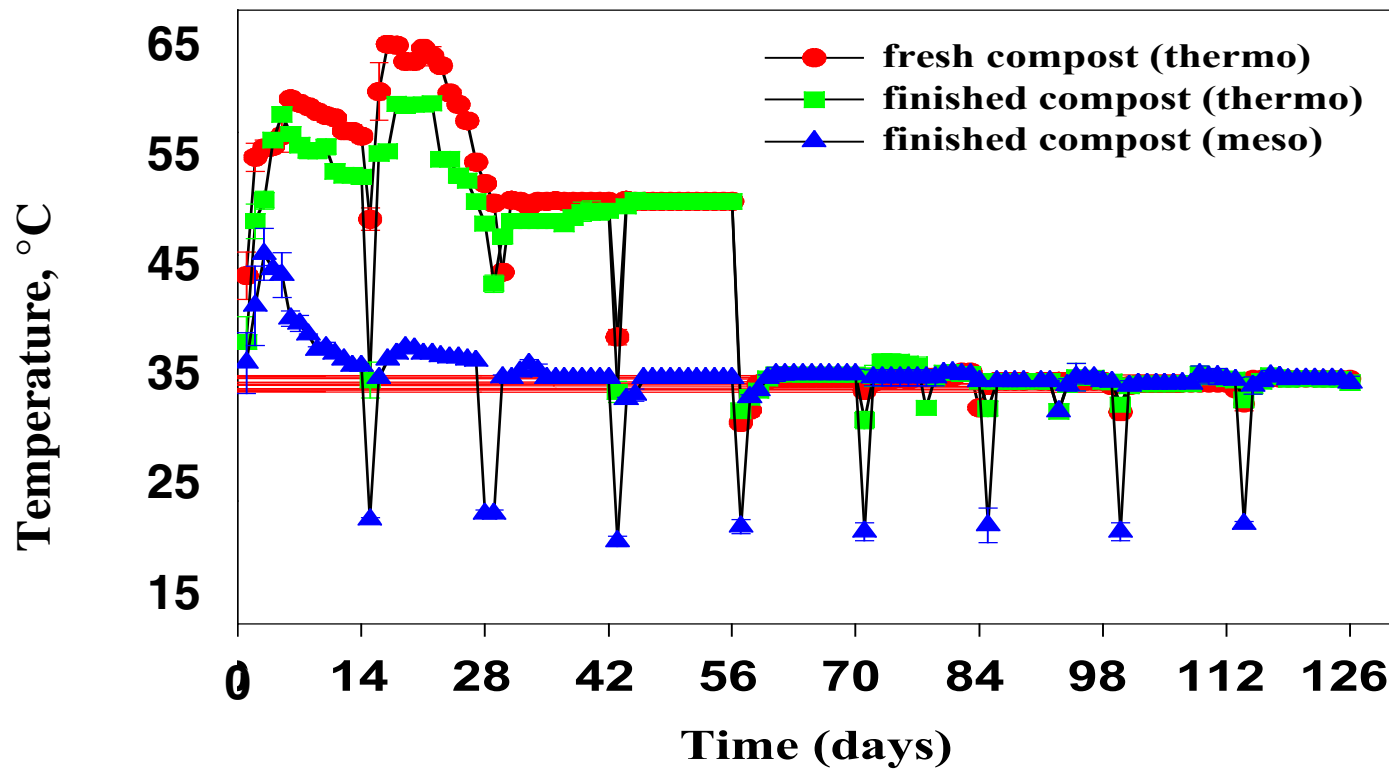
- **$^{14}\text{C}$  CO<sub>2</sub> Production**
  - **exhaust gas trap**
- **Extractable  $^{14}\text{C}$  Residues**
  - **a consecutive step extraction**
- **Extractable Diesel Range Organics (EDRO)**
  - **EPA Method**



- **Volatile Solids Removal**
  - **mass balance**
- **Moisture Content**
  - **Rapid Methods**

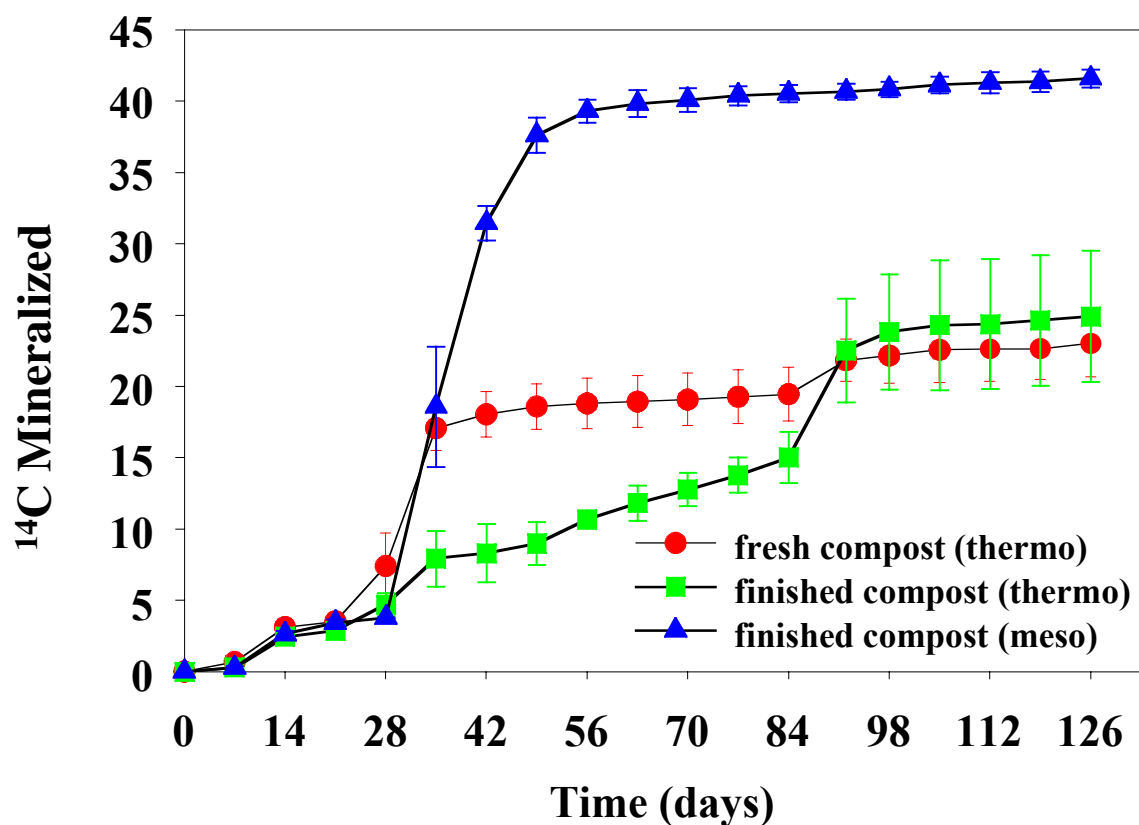
# Results

## Mean Temperature Profiles



# Results

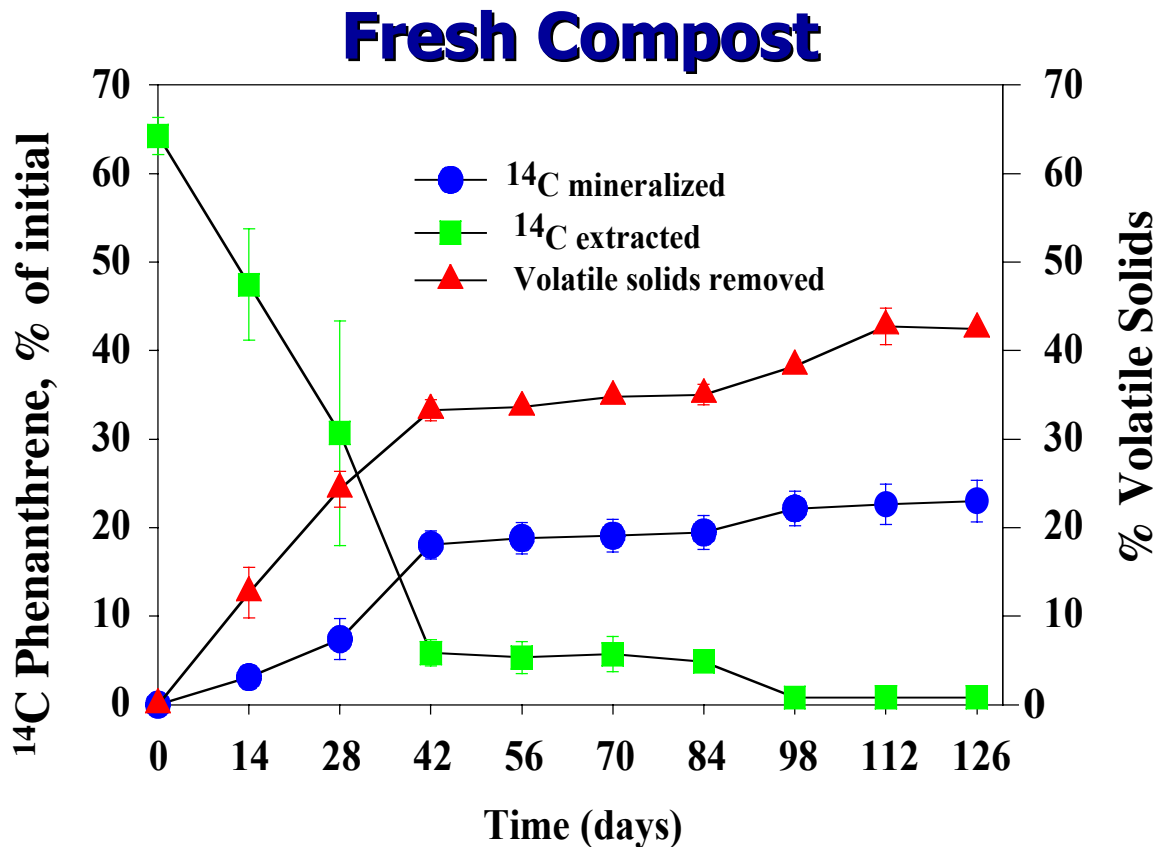
## Mineralization of $^{14}\text{C}$ Phenanthrene



- No release of  $^{14}\text{CO}_2$  from soil with no compost
- No significant difference between compost age at 126 days
- Significant difference between temperatures

# Results

## Volatile Solids & $^{14}\text{C}$ Recovery at Thermophilic Temperature Pattern

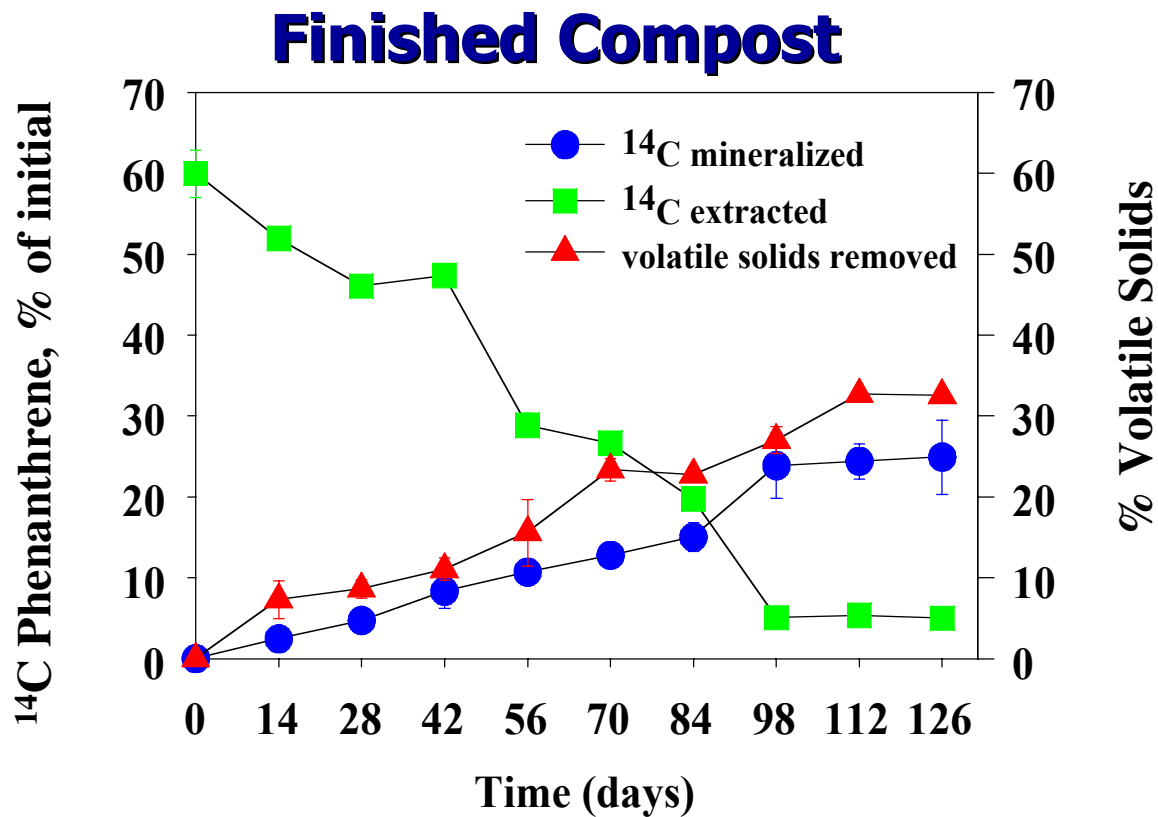


- VS reduction was not a major factor in decreasing of mineralization rate
- Amount extracted decreased to <1%
- Correlation existed between extracted and mineralized



# Results

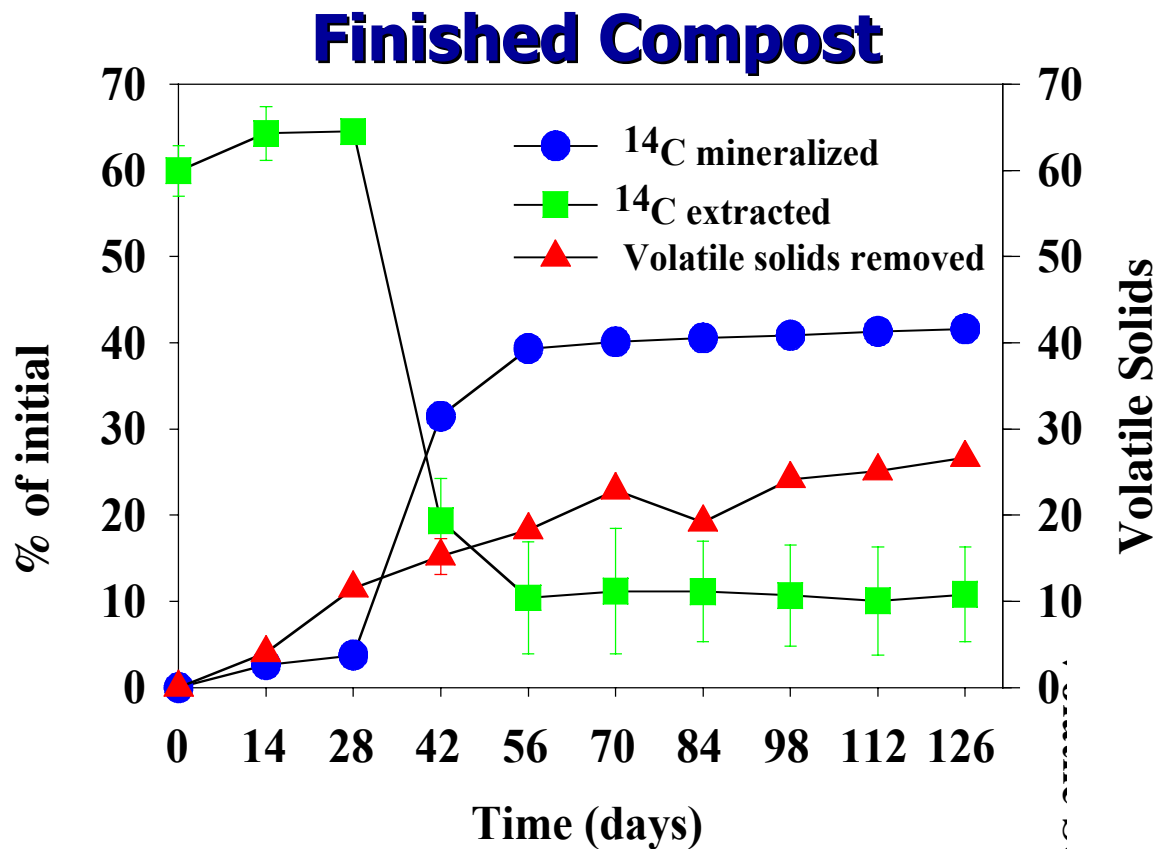
## Volatile Solids & $^{14}\text{C}$ Recovery at Thermophilic Temperature Pattern



- VS reduction was not a major factor in decreasing of mineralization rate
- Amount extracted decreased to 5%
- Correlation existed between extracted and mineralized

# Results

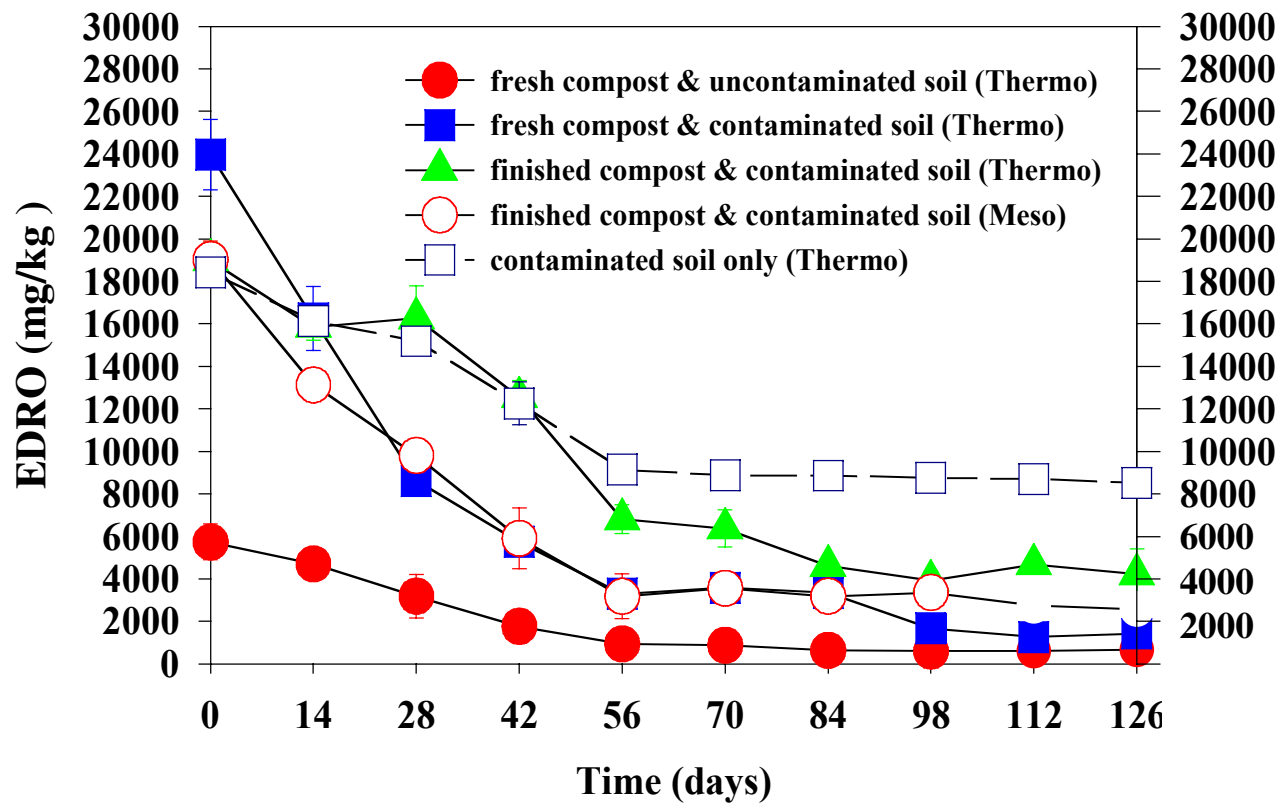
## Volatile Solids & $^{14}\text{C}$ Recovery at Mesophilic Temperature Pattern



- VS reduction was not a major factor in decreasing of mineralization rate
- Amount extracted decreased to 10%
- Correlation existed between extracted and mineralized

# Results

## Extractable Diesel Range Organics

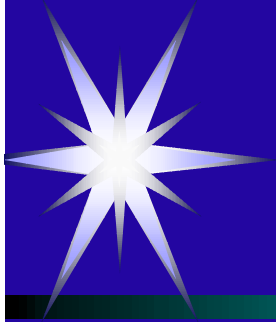


- Compost had dramatic impact on EDRO
- 74% to 94% removal achieved
- Fresh compost removed more EDRO



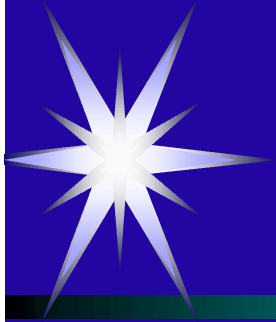
# Summary

- No mineralization of Phenanthrene was observed with no compost addition.
- 25 to 40% of phenanthrene was mineralized with addition of compost.
- Fresh compost showed a higher mineralization rate than the finished compost at thermophilic temperature.
- Finished compost at mesophilic temperature resulted in much higher mineralization rates when compared to thermophilic temperature.



## Summary (Cont..)

- The reduction of extractable phenanthrene in both temperatures was accompanied by the reduction of phenanthrene evolved as  $^{14}\text{CO}_2$ .
- The EDRO remaining was approaching the Manitoba clean-up guidelines for residential land use.



# Conclusions

- Thermophilic temperature had negative impact on the rate and end point of phenanthrene mineralization.
- Finished compost and mesophilic temperatures were the best combination for the phenanthrene mineralization and removal of diesel fuel hydrocarbons from the aqueous phase.
- Composting removed more EDRO but left more Phenanthrene that may cause toxicity.
- Toxicity tests would be performed on plants and earthworms to evaluate the composting treatment.