

# ENHANCED HYDROCARBON BIOREMEDIATION THROUGH THE ADDITION OF HUMIC SUBSTANCES PART II: IMPROVED LAND TREATMENT AND STATIC-PILE COMPOSTING



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# RATIONALE

- ❖ **POTENTIAL HYDROCARBON CONTAMINATION IN SOIL**
- ❖ **HUMIC SUBSTANCES IMPROVE SOIL QUALITY → ENHANCING HYDROCARBON BIODEGRADATION**
- ❖ **EXCELLENT POTENTIAL MARKET OVER LANDFILLING**



# SCOPE OF WORK

- ❖ **IMPROVED PERFORMANCE OF HUMIC SUBSTANCES IN ENHANCING HYDROCARBON BIODEGRADATION → BULKING AGENTS AND SOIL ADDITIVES ADDITION**
- ❖ **LABORATORY EXPERIMENTS OF LAND TREATMENT AND STATIC-PILE COMPOSTING**



# GUIDELINES

- ❖ **CANADIAN COUNCIL OF MINISTRIES OF THE ENVIRONMENT (CCME)**
- ❖ **TIER I FOR PETROLEUM HYDROCARBONS (PHC)**
- ❖ **AGRICULTURAL APPLICATION FOR FINE GRAIN SOIL**



# TREATMENT ALTERNATIVES

- ❖ **LAND TREATMENT: LOWER CAPITAL & OPERATION, LESS OPTIMIZED PROCESS**
- ❖ **STATIC-PILE COMPOSTING: HIGHER CAPITAL & OPERATION, MORE OPTIMIZED PROCESS**



# LAND TREATMENT

- ❖ **300 MM DEPTH**
- ❖ **MANUAL TILLING**
- ❖ **MESOPHILIC**
- ❖ **C:N = 20 TO 25:1**
- ❖ **50 TO 75% FIELD CAPACITY**



# STATIC-PILE COMPOSTING

- ❖ **2 TO 3 M DEPTH**
- ❖ **FORCED AERATION**
- ❖ **THERMOPHILIC**
- ❖ **C:N = 20 TO 25:1**
- ❖ **50 TO 75% FIELD CAPACITY**



# SOIL PROPERTIES

Parameter	Unit	Value
Moisture	%	23
Field Capacity	%	85
Porosity	%	50
Bulk Density	kg/m <sup>3</sup>	1,000
Clay	%	63
Silt	%	22
Sand	%	15
Total Carbon	%	2.4
Total Nutrient	%	0.34
pH	-	7.3
HPC	#/g	1,100





# HYDROCARBON CONTAMINANT

- ❖ **DIESEL: 97% C<sub>7</sub> TO C<sub>22</sub> @ 36.1 TO 503.0°C**
- ❖ **EVAPORATION < 0.1% @ 36 TO 69 °C**



# HYDROCARBON BIODEGRADATION

- ❖ **IMPROVE SOIL QUALITY**
- ❖ **INCREASE HYDROCARBON SOLUBILITY IN SOIL**
- ❖ **ENHANCE GROWTH OF SOIL MICROORGANISMS**



# HUMIC SUBSTANCES

- ❖ **PROVIDE AVAILABLE CARBON TO SOIL**
- ❖ **MAINTAIN SOIL PH AROUND NEUTRAL**
- ❖ **INCREASE SOLUBILITY OF HYDROCARBONS IN SOIL**
- ❖ **IMPROVE WATER RETENTION IN SOIL**
- ❖ **DISSOLVE CLAY AGGREGATE**
- ❖ **RETAIN MICRONUTRIENTS IN SOIL**



# HUMIC SUBSTANCES (Cont'd)

Parameter	Unit	Value
Organics	%	55
pH	-	7.0 to 7.4
Bulk Density	kg/m <sup>3</sup>	866 to 965
Particle Size		
75 to 180	micron	17%
< 75	micron	83%



# BULKING AGENTS

- ❖ **IMPROVE SOIL POROSITY**
- ❖ **PROVIDE AVAILABLE NUTRIENTS**
- ❖ **INCREASE INITIAL NUMBER OF MICROORGANISMS**
- ❖ **PROVIDE MEDIUM FOR MICROORGANISMS GROWTH**



# BULKING AGENTS (Cont'd)

Parameter	Unit	Compost	Wood-Mulch
Moisture	%	29	62
Field Capacity	%		
Porosity	%	50	50
Bulk Density	kg/m <sup>3</sup>	585	250
Particle Size	%	18 (> 4 mm)	39 (> 4 mm)
	%	57 (0.5 to 4 mm)	53 (0.5 to 4 mm)
	%	25 (< 0.5 mm)	8 (< 0.5 mm)
Total Carbon	%	18.2	38.7
Total Nitrogen	%	0.94	0.88
pH	-	7.2	7.1
HPC	#/g	250E6	77E6



# SOIL ADDITIVES

- ❖ **IMPROVE HYDROCARBON DEGRADATION**
- ❖ **ENHANCE MICROORGANISMS GROWTH**



# SOIL ADDITIVES (Cont'd)

Component	% (by weight)
Extra-cellular enzymes	10
Biostimulants:	
Bacterial culture	60
Nutrients	30





# EXPERIMENTAL DESIGN: Land Treatment

- ❖ **DIESEL: 0.25 TO 0.5 % BY WEIGHT**
- ❖ **HUMIC SUBSTANCES: 0 AND 5% BY WEIGHT**
- ❖ **BULKING AGENTS: 0 AND 50% BY WEIGHT**
- ❖ **SOIL ADDITIVES: 0 AND 0.1% BY WEIGHT**
- ❖ **TEMPERATURE: AMBIENT @ 20 °C**
- ❖ **AERATION: TILLING**
- ❖ **MISTURE: 50% BY WEIGHT**

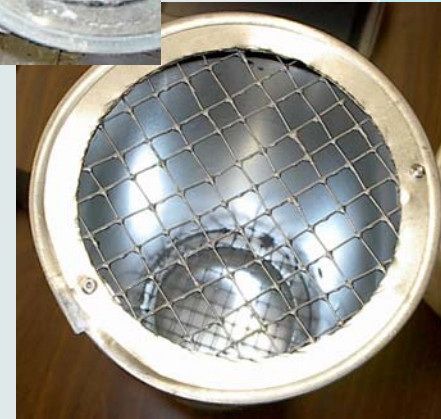


# EXPERIMENTAL DESIGN: Static-Pile Composting

- ❖ **DIESEL: 0.25 TO 0.5 % BY WEIGHT**
- ❖ **HUMIC SUBSTANCES: 0 AND 5% BY WEIGHT**
- ❖ **BULKING AGENTS: 0 AND 50% BY WEIGHT**
- ❖ **TEMPERATURE: HEATED TO 50 °C**
- ❖ **AERATION: FORCED**
- ❖ **MOISTURE: 50% BY WEIGHT WEEKLY**



# LABORATORY EQUIPMENT



  
**HOODGROUP**

**BLACK EARTH™**  
ENHANCING...NATURALLY

# MONITORING & SAMPLING

- ❖ **MOISTURE CONTENTS: WEEKLY**
- ❖ **SOIL AGGREGATE SIZE: WEEKLY**
- ❖ **TOTAL C & N, HPC, PH, TEH: TRI-WEEKLY**



# MOISTURE RETAINING

Soil Mixture	Before Adjustment (%)	After Adjustment (%)	Moisture Retaining (%)
Soil	66(8.4)	48(11.4)	72(11.7)
Soil+bulking agents	71(10.0)	49(12.0)	68(11.5)
Soil+humic (1%)	64(7.5)	50(9.8)	78(10.0)
Soil+humic (5%)	60(6.7)	53(8.4)	87(9.2)
Soil +humic(1%)+bulking agents	66(9.5)	50(10.0)	75(10.5)
Soil+humic(5%)+bulking agents	62(7.0)	54(8.1)	86(7.2)



# AGGREGATE SIZE

Soil Mixture	Aggregate Size Distribution (%)		
	≥ 4.0 mm	2.4 to 4.0 mm	1.4 to 2.4 mm
Soil	88(4.9)	5(1.7)	2(3.20)
Soil+bulking agents	76(3.9)	11(8.8)	4(3.4)
Soil+humic (1%)	84 (3.4)	6 (1.9)	3 (1.2)
Soil+humic (5%)	70 (11.2)	13 (4.5)	6 (3.8)
Soil+humic(1%)+bulking agents	73(9.7)	14(6.9)	6(3.1)
Soil+humic(5%)+bulking agents	75(8.7)	13(4.4)	4(3.0)

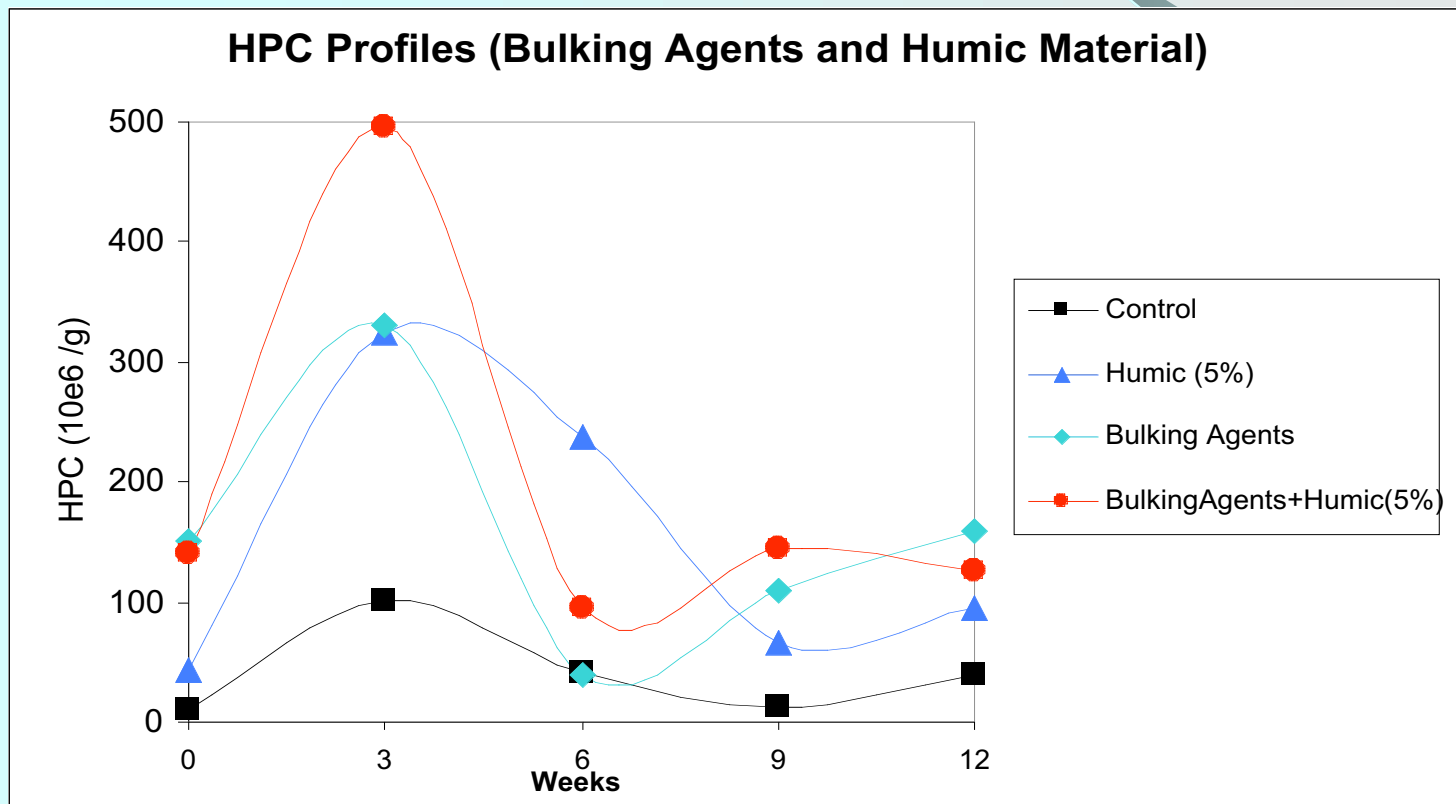


# pH & C:N

Soil Mixture	Initial Week Values	
	pH	C:N
Soil	7.6	7
Soil+bulking agents	7.4	14
Soil+humic (1%) <sup>1</sup>	7.4	9
Soil+humic (5%) <sup>1</sup>	7.2	14
Soil+humic (1%)+bulking agents	7.4	17
Soil+humic (5%)+bulking agents	7.2	21
Soil+additives (enzymes)	7.4 - 7.5	13 - 14
Soil+additives (enzymes+biostimulants)	7.4 - 7.5	13 - 14
Soil+humic(1%)+additives(enzymes)	7.1 - 7.4	17 - 19
Soil+humic(5%)+additives(enzymes+biostimulants)	7.0 - 7.2	16 - 24

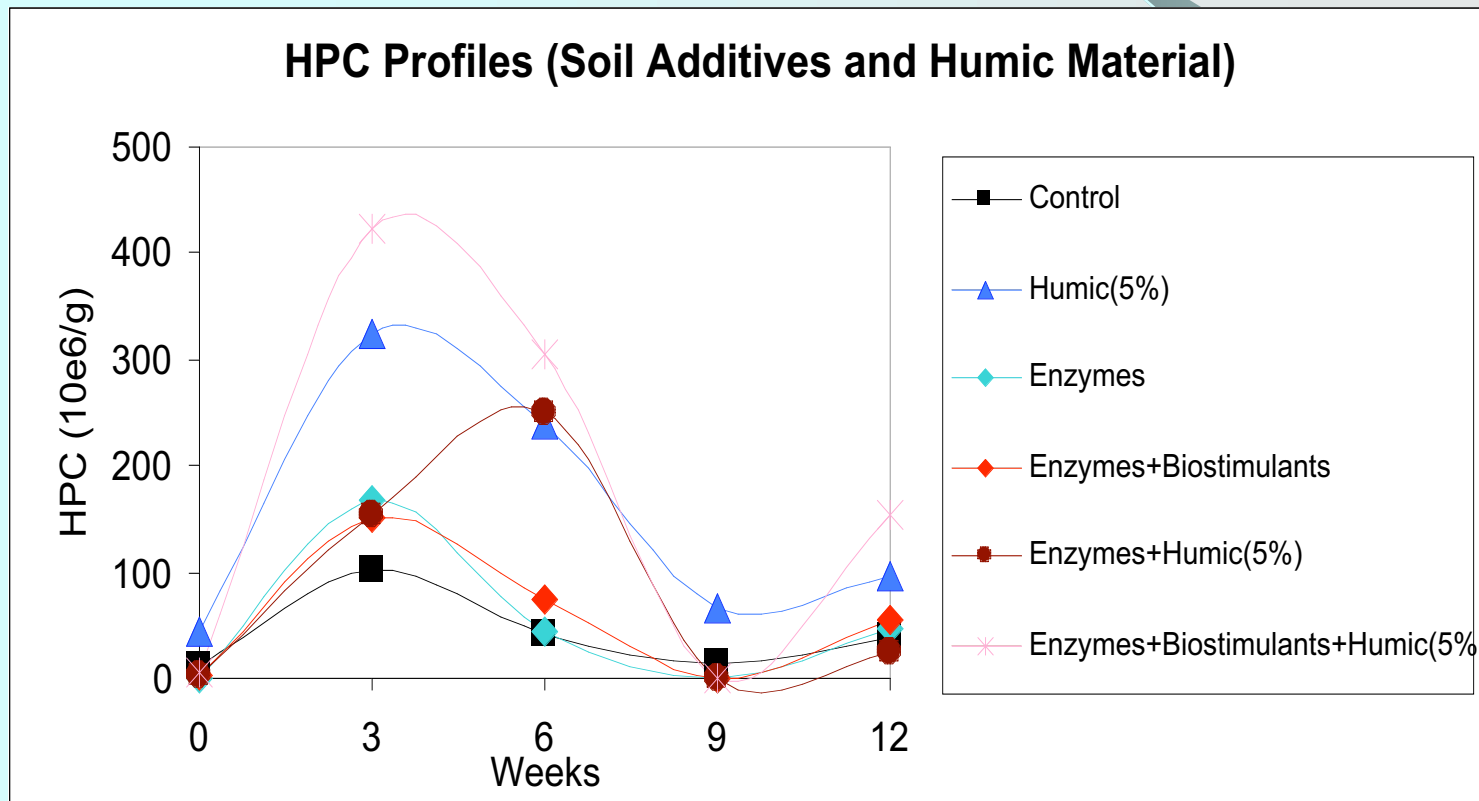


# HPC PROFILES

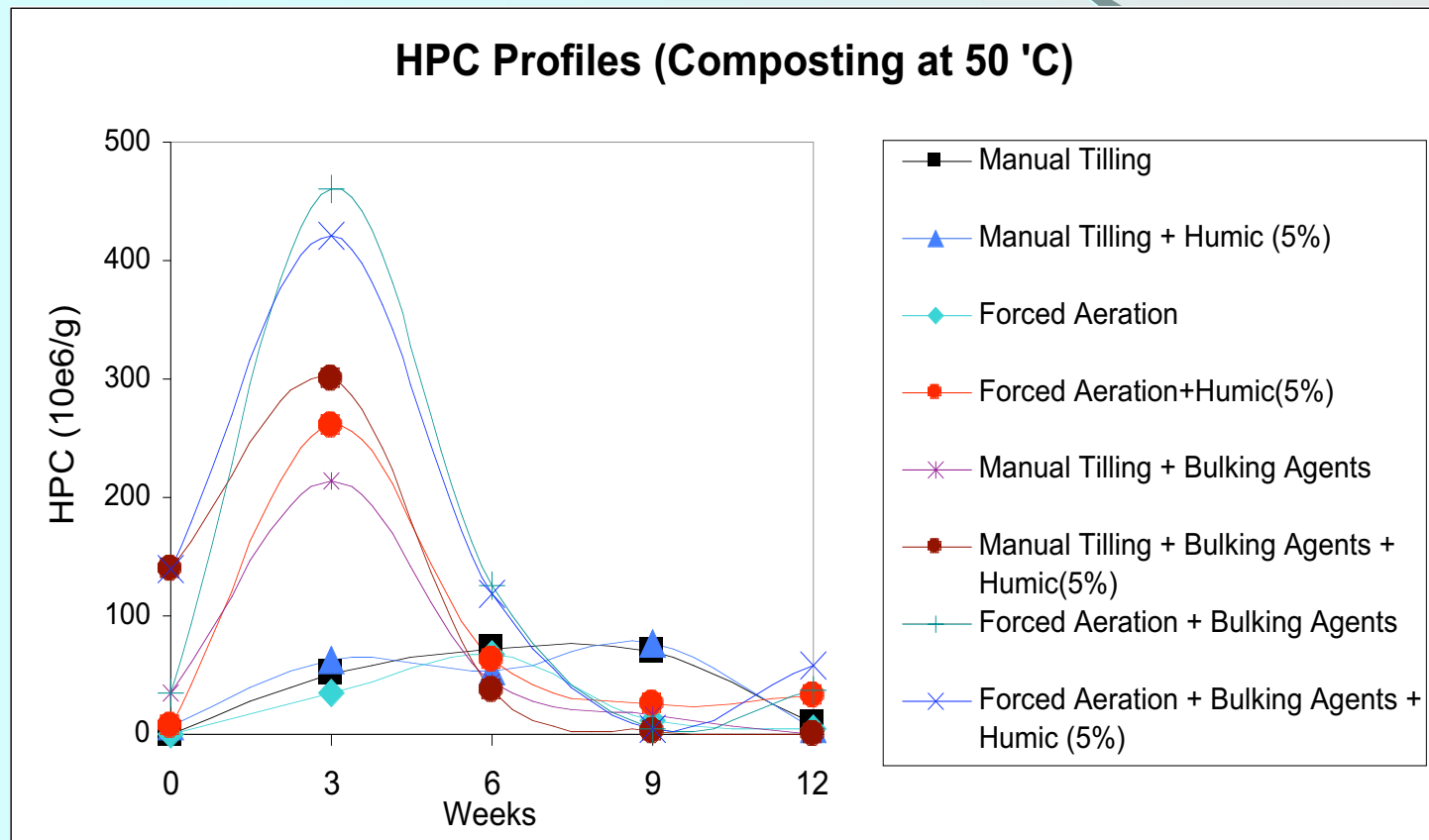




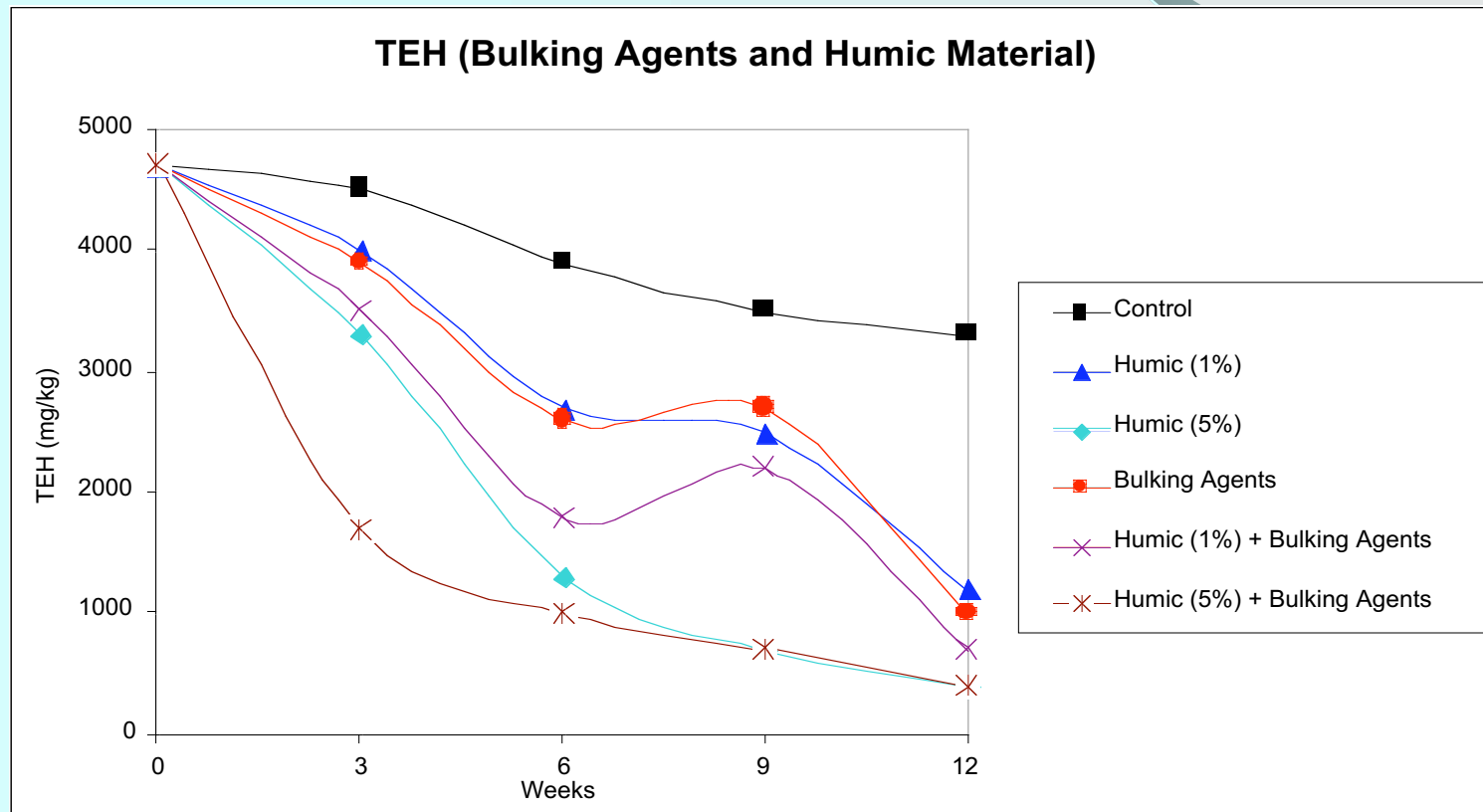
# HPC PROFILES (Cont'd)



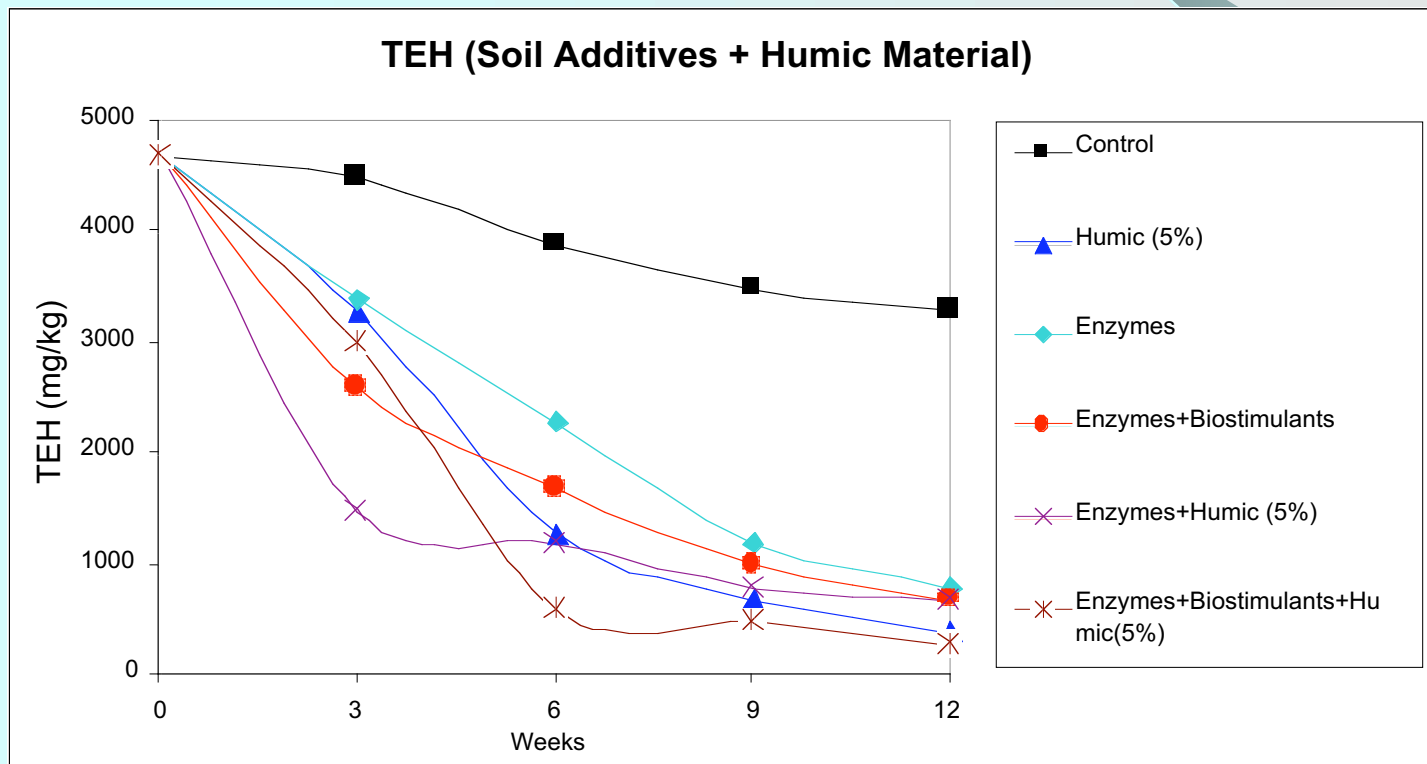
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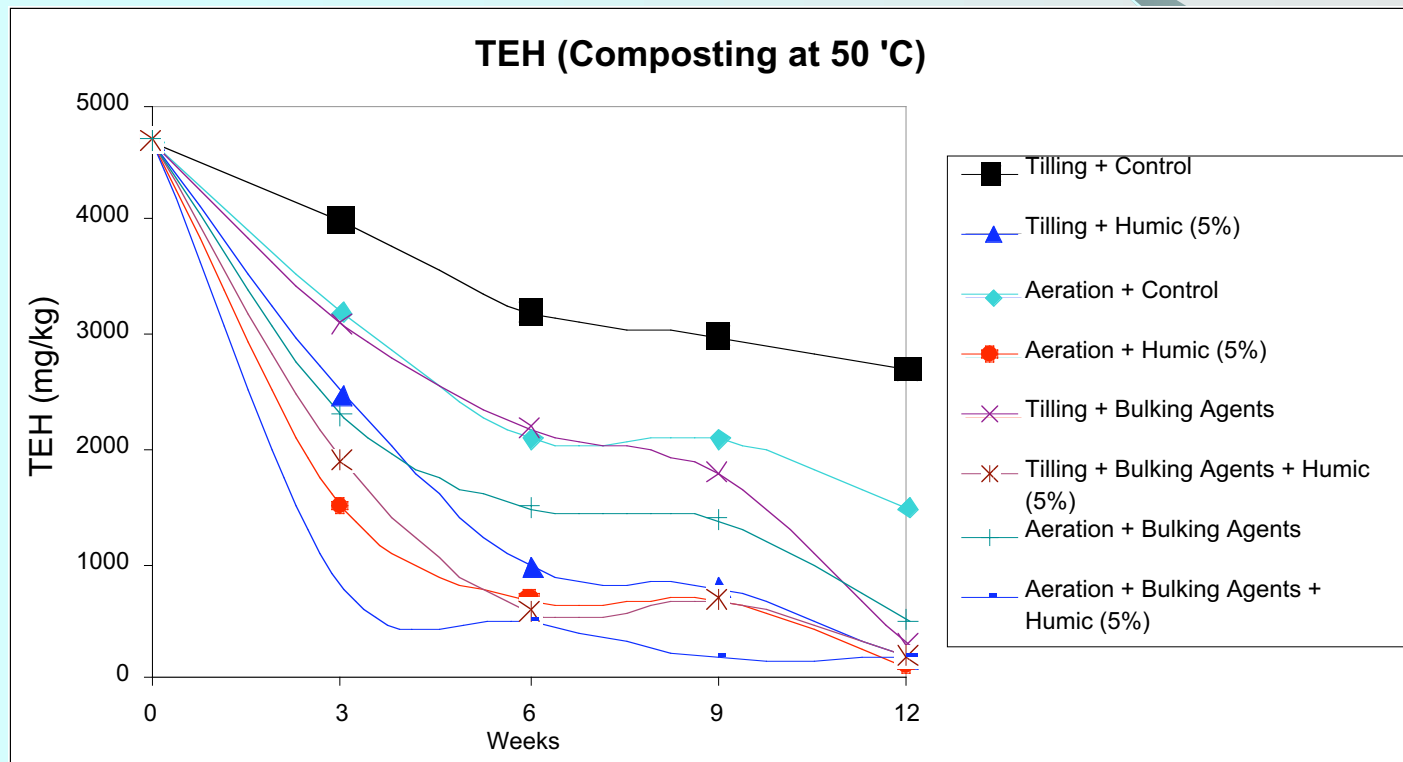
# TEH PROFILES



# TEH PROFILES (Cont'd)



# TEH PROFILES (Cont'd)



# LAND TREATMENT SUMMARY

No	Treatment	Tier I Objective (800 mg/kg)
1	Control	3,300 mg/kg @ 12 weeks
2	Humic @ 1%	1,200 mg/kg @ 12 weeks
3	Humic @ 5%	Tier I @ 9 to 12 weeks
4	Bulking Agents @ 50%	1,000 mg/kg @ 12 weeks
5	2 + 4	Tier I @ 12 weeks
6	3 + 4	Tier I @ 6 to 9 weeks
7	Soil additives (enzymes) @ 0.1%	1,000 mg/kg @ 12 weeks
8	Soil additives (enzymes+biostimulants)@ 0.1%	Tier I @ 12 weeks
9	3 + 7	Tier I @ 6 to 9 weeks
10	3 + 8	Tier I @ 3 to 6 weeks



# STATIC-PILE COMPOSTING SUMMARY

No	Treatment	Aeration	Tier I Objective (800 mg/kg)
1	Control	Tilling	2,700 mg/kg @ 12 weeks
2	Control	Aeration	1,600 mg/kg @ 12 weeks
3	Humic @ 5%	Tilling	Tier I @ 6 to 9 weeks
4	Humic @ 5%	Aeration	Tier I @ 6 to 9 weeks
5	Bulking Agents @ 50%	Tilling	Tier I @ 9 to 12 weeks
6	Bulking Agents @ 50%	Aeration	Tier I @ 9 to 12 weeks
7	3 + 5	Tilling	Tier I @ 6 to 9 weeks
8	4 + 6	Aeration	Tier I @ 3 to 6 weeks



# TREATMENT ALTERNATIVES SUMMARY

- ❖ Forced aeration outperformed tilling
- ❖ Higher temperature was better





# HUMIC SUBSTANCES SUMMARY

- ❖ Improve soil quality
- ❖ Enhance microorganisms growth
- ❖ Enhance diesel biodegradation



# BULKING AGENTS & SOIL ADDITIVES SUMMARY

- ❖ Improve humic substances performance
- ❖ Enhance microorganisms growth and diesel biodegradation
- ❖ Optimum dosages to be determined more thoroughly



# ENHANCED BIODEGRADATION SUMMARY

- ❖ Shorter timeline for Tier I
- ❖ Simpler operation & optimization
- ❖ Cost factors to be considered
- ❖ Different hydrocarbons to be tested

