ENVIRONMENTAL PARAMETER OPTIMIZATION FOR BIOREMEDIATION OF PETROLEUM HYDROCARBON CONTAMINATED SOIL

Richard Scholze

U.S. Army Corps of Engineers

ERDC-CERL, Champaign, IL

Jeff Salmon

Fort Hood Environmental Mgmt Branch

Fort Hood, TX

BIOREMEDIATION

Defn. - Use of Microorganisms to Remove Pollutants

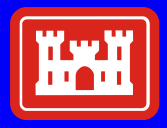
Complex Process in the Environment

- Nature and Amount of Pollutant Present
- Ambient and Seasonal Environmental Conditions
- Composition of Indigenous Microbial Community

BIOREMEDIATION

Can be Applied to Sites Contaminated with a Variety of Chemical Pollutants

Our Focus – Monoaromatic Hydrocarbons – e.g. Benzene, Toluene, Xylene and Other Petroleum Products as Represented by Total Petroleum Hydrocarbons (TPH)

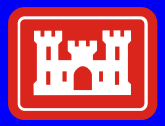


LANDFARMING

Environmental Modification

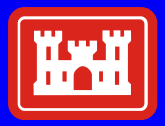
Effectiveness Depends on Parameter Groups by USEPA

- Soil Characteristics
- Constituent Characteristics
- Climatic Conditions



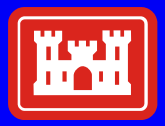
SOIL CHARACTERISTICS

- Microbial Population Density
- Soil pH
- Moisture Content
- Soil Temperature
- Nutrient Concentrations
- Soil Texture



CONSTITUENT CHARACTERISTICS

- Volatility
- Chemical Structure
- Concentration and Toxicity

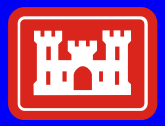


CLIMATIC CONDITIONS

Ambient Temperature

Rainfall

Wind



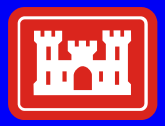
BIOREMEDIATION

- End Products – Nontoxic, Water and Carbon Dioxide
- No Harm to Environment or Living Organisms
- Advantage: Inexpensive Compared to Physical Methods
- Not Panacea – Limited in Materials Which Can Be Treated, Site Conditions and Time Available for Treatment

BIOREMEDIATION EFFICACY

Monitoring Disappearance of Pollutant

Be Aware of Other Factors: Evaporation, Photodegradation and Leaching



ENVIRONMENTAL LIMITATIONS

Excessively High Waste Concentrations

Lack of Oxygen

Unfavorable pH

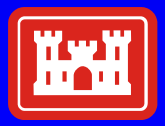
Lack of Nutrients

Lack of Moisture

Unfavorable Temperature

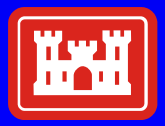
MICROORGANISMS ARE UBIQUITOUS

Correct the Environmental Conditions and Usually Should be a Spontaneous Enrichment of Appropriate Microorganisms



ENVIRONMENTAL PARAMETERS

- Oxygen – Ensure Adequate Drainage and Pore Space for Diffusion
- Solution – Cultivation, Plowing, Rototilling
- Nutrients – Nitrogen and Phosphorous Incorporated into Biomass
- Solution – Generally Add as Agricultural Fertilizer to Surface Soils
- Water – Appropriate to Maintain Moisture
- pH – May Require Adjustment



CURRENT SITUATION

Existing State-of-the Art Biosite

Treat POL – Contaminated Soil, Washrack Waste

Remediate to Final Use as Landfill Cover

-TPH <600 mg/kg

Spending $50,000 per Year for “Bugs”

-Proprietary Inoculum

Is This Necessary?

STUDY CONDITIONS

Manipulate Environmental Parameters: Nutrients, Water, and Soil Aeration Under Consistent Climatic Exposure and Compare with Soil Treated with Proprietary Inoculatory Microorganisms

Take Soil From Staging Area and Treat with Defined Regimen

Monitor Environmental and Analytical Parameters

at Start, Interim and Final Time Periods to Desired Final Endpoint

US Army Corps of Engineers

Engineer Research and Development Center


A

US Army Corps
of Engineers

Engineer Research and Development Center

STUDY PHASE 1

POL-Contaminated Soil at Staging Area Thoroughly Mixed

Soil Divided and Spread at Biosite and Treated, One Sample with Inoculum, Other Without, Watered and Tilled Identically, Climate Exposure Identical, No pH Adjustment, Inoculum Fertilized with 21-0-0 Fertilizer, Other with 18-10-5

Parameters Monitored

Project Length - 199 days

REGULAR vs. NATURAL COMPARISON (PHASE 1)

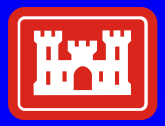
	Regular Method	Natural Method	Decrease
Remediation Time	229	229	
Total Cost/Yd^3 ($)	7.98	4.50	3.48
Cost without lab ($)	2.06	0.85	1.21
Material Cost/Yd^3 ($)	0.94	0.19	0.75
Labor Cost/Yd^3 ($)	1.12	0.66	0.46
Labor Hours/Yd^3	0.05	0.03	.02
TPH Start (mg/kg)	4360	5440	
TPH Final (mg/kg)	66	72	

STUDY PHASE 2

- POL-Contaminated Soil at Staging Area Thoroughly Mixed
- Soil Divided and Spread at Biosite and Treated, One Sample with Inoculum, Other Without, Watered and Tilled Identically, Climate Exposure Identical, No pH Adjustment, Inoculum Fertilized with 21-0-0 Fertilizer, Other with 18-10-5
- 2 Other Commercial Additives Used per Vendor's Direction
- Parameters Monitored
- Project Length – 37-52 days

REGULAR vs. NATURAL COMPARISON (Phase 2

	Regular Method	Natural Method	% Decrease
Remediation Time	52	37	29
Total Cost/Yd^3 ($)	6.25	1.31	79
Material Cost/Yd^3 ($)	2.26	0.11	95
Labor Cost/Yd^3 ($)	3.89	1.20	69
Labor Hours/Yd^3	0.17	0.05	71
TPH Start (mg/kg)	675	484	
TPH Final (mg/kg)	127	55	

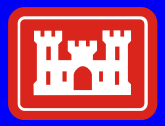


NATURAL METHOD VS. COMMERCIAL METHODS PHASE 2

	Natural Method	Commercial #1	Commercial #2
Remediation Time	37	37	52
Total Cost/Yd^3 ($)	1.31	9.43	8.81
Material Cost/Yd^3 ($)	0.11	6.46	4.23
Labor Cost/Yd^3 ($)	1.20	2.97	4.58
Labor Hours/Yd^3	0.05	0.13	0.20
TPH Start (mg/kg)	484	433	2480
TPH Final (mg/kg)	55	37	96

SUMMARY

- Natural method more cost-effective than regular method AND two volunteer commercial methods
- Regular aeration and irrigation single most important aspect
- Fertilizer essential, additional nutrients valuable



QUESTIONS?

Contact Information

Richard Scholze
217-398-5590 or email r-scholze@cecer.army.mil

Jeff Salmon
254-287-9184 or email Jeff.Salmon@us.army.mil