

US EPA ARCHIVE DOCUMENT

ENVIRONMENTAL PARAMETER OPTIMIZATION FOR BIOREMEDIATION OF PETROLEUM HYDROCARBON CONTAMINATED SOIL

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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**



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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)**



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LANDFARMING

Environmental Modification

Effectiveness Depends on Parameter Groups by USEPA

Soil Characteristics

Constituent Characteristics

Climatic Conditions



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SOIL CHARACTERISTICS

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



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CONSTITUENT CHARACTERISTICS

Volatility

Chemical Structure

Concentration and Toxicity



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CLIMATIC CONDITIONS

Ambient Temperature

Rainfall

Wind



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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



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BIOREMEDIATION EFFICACY

**Monitoring Disappearance of Pollutant
Be Aware of Other Factors: Evaporation,
Photodegradation and Leaching**



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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**



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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?



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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



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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



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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	



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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



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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	



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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



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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



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QUESTIONS?

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