

Performance of Enhanced Aerobic Bioremediation on Remediating Upstream Oilfield Wastes



Introduction

Historical Experience With Bioremediation


- * Well Established, Proven Technology
- * Medium-to-Long Term Approach
- * Conventional Methods Exhibit Potential To Stall Out

Ways To Improve Utility of Bioremediation

- * Accelerate Degradation Rates
- * Reduce Treatment Times
- * Degradation of More Recalcitrant Organic Compounds

Overview Of Enhanced Aerobic Bioremediation Process

Key Elements:

- * Chemical Agent Blended W/ Nutrients
 - * Viable Bacteria Source
 - * Homogeneous Slurry Mix
 - * Critical Environment Management
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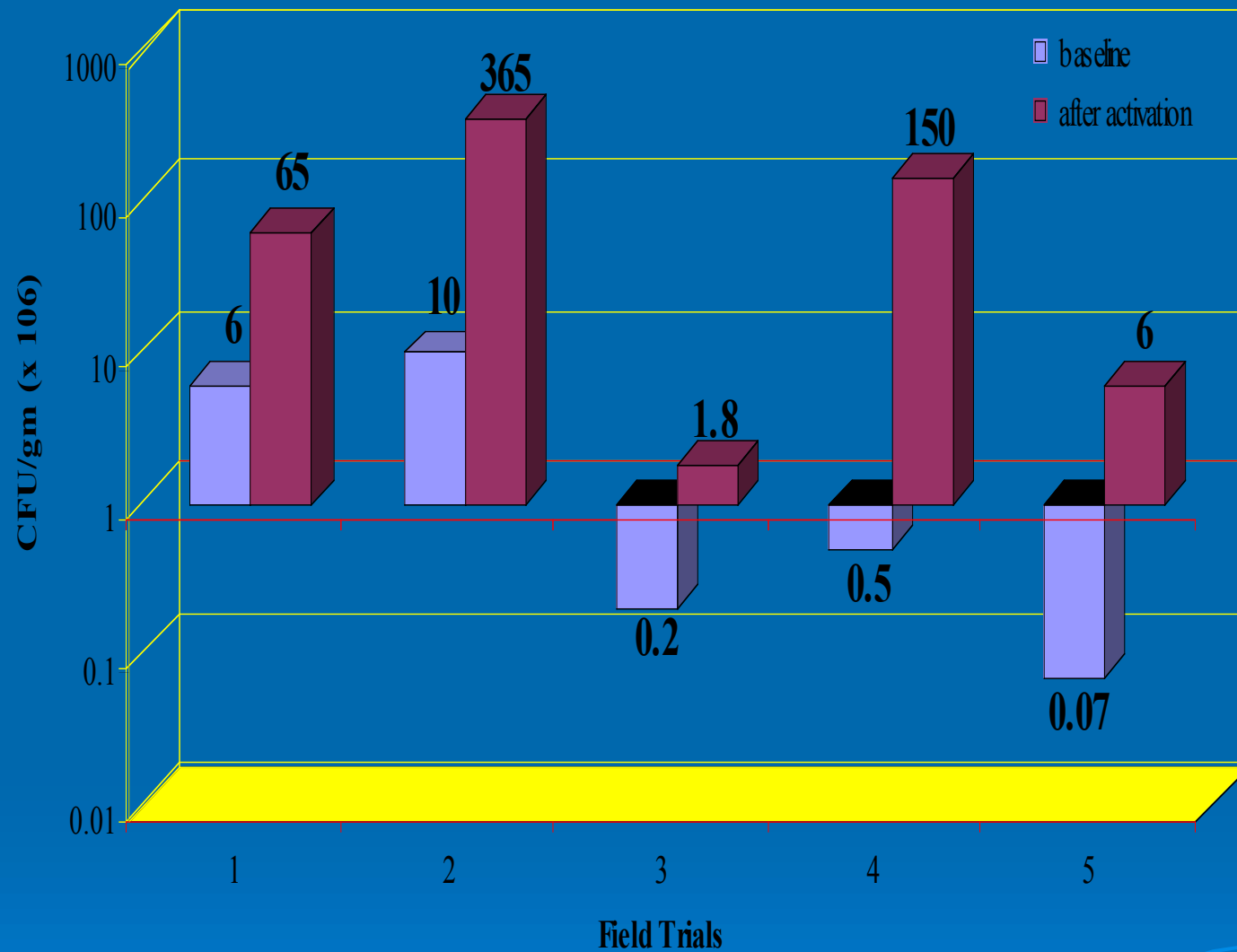
Chemical Agent

- * Base Formulation Contains A Non-Ionic Surfactant
- * Biodegrades In Sixteen Days In Aqueous Solution
- * Solubilizer Not Dispersant/Emulsifier
- * Non-Toxic (LC 50 Mortality)
 - Shrimp - *Mysidopsis bahia*
 - Trout - *Oncorhynchus mykiss*

Chemical Agent Characteristics

✱ Promotes Microbial Growth

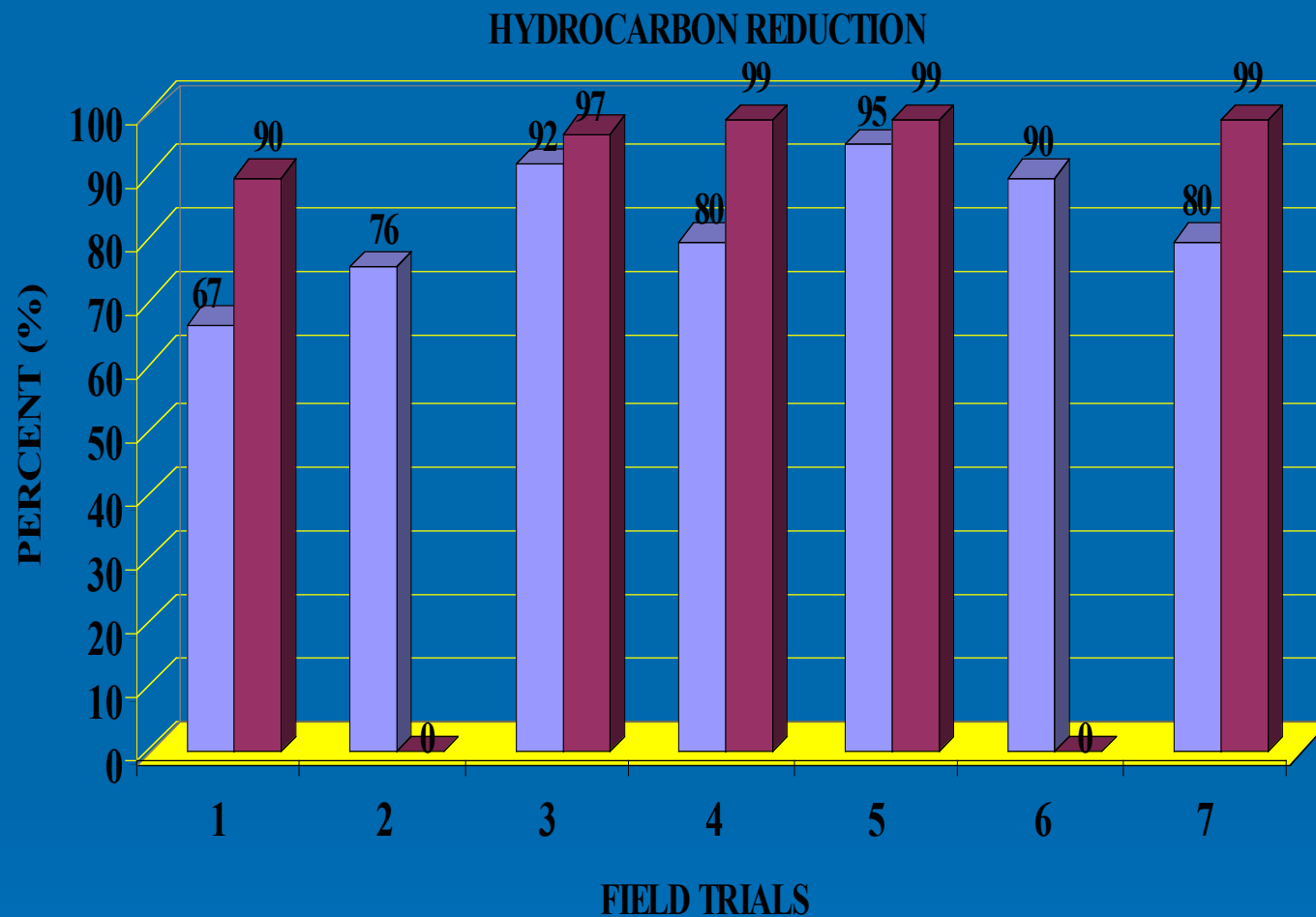




Chemical Effect on Microorganisms

Chemical Agent Characteristics

- ✱ Promotes Microbial Growth
- ✱ Increases Contaminant Solubility
- ✱ Increases Contaminant Bioavailability



Chemical Effect on Concentration
Reduction

Treatment Process

Biocell Construction



Treatment Process

Biocell Construction



Treatment Process

Biocell Construction

Spread Contaminant In Lifts



Treatment Process

Contaminant Loading



Treatment Process

Biocell Construction

Spread Contaminant In Lifts

Mixing In Soil Amendment



Treatment Process

Blending In Soil Amendment



Treatment Process

Biocell Construction

Spread Contaminant In Lifts

Mixing In Soil Amendment

Application of Chemical Agent



Treatment Process

Chemical Mixing



Treatment Process

Topical Application of Chemical



Treatment Process

Biocell Construction

Spread Contaminant In Lifts

Mixing In Soil Amendment

Application of Chemical Agent

Maintenance and Tillage



Treatment Process

Treatment Mixing & Maintenance



Treatment Process

Homogeneous Slurry



CASE STUDY 1

Controlled Field Trial

Contaminant – Oil-Based Drilling Mud

Initial PHC Concentration Range

3.2% - 3.5%



CS 1 Applications

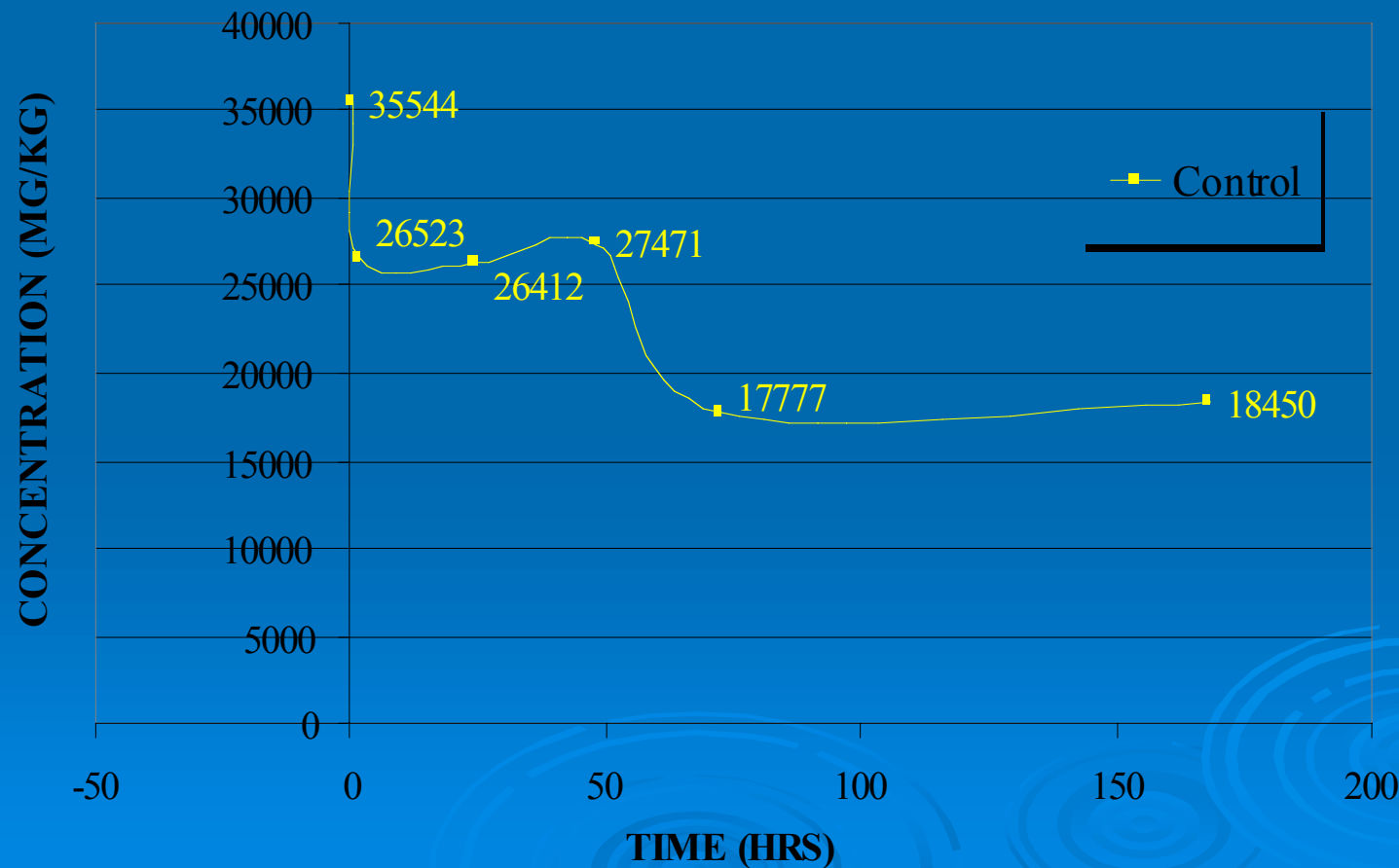
Test Plot	Amendments	Application Rate (L/m³)	Application Ratio (Chem/Wtr)
Control	Soil, Water	NA	NA
Treated	Soil, Water, Chemical	7.6 (2 gals)	1:20

CS 1 Operating Parameters

Parameter	Value
Mixing Frequency	Daily
Moisture Content	13 - 21 % by weight
Residence Time	Maximum Treatment Period-7 days
Temperature	Ambient (24-33 °C)

CS 1 PHC Concentration Reduction-Control

PHC DEGRADATION

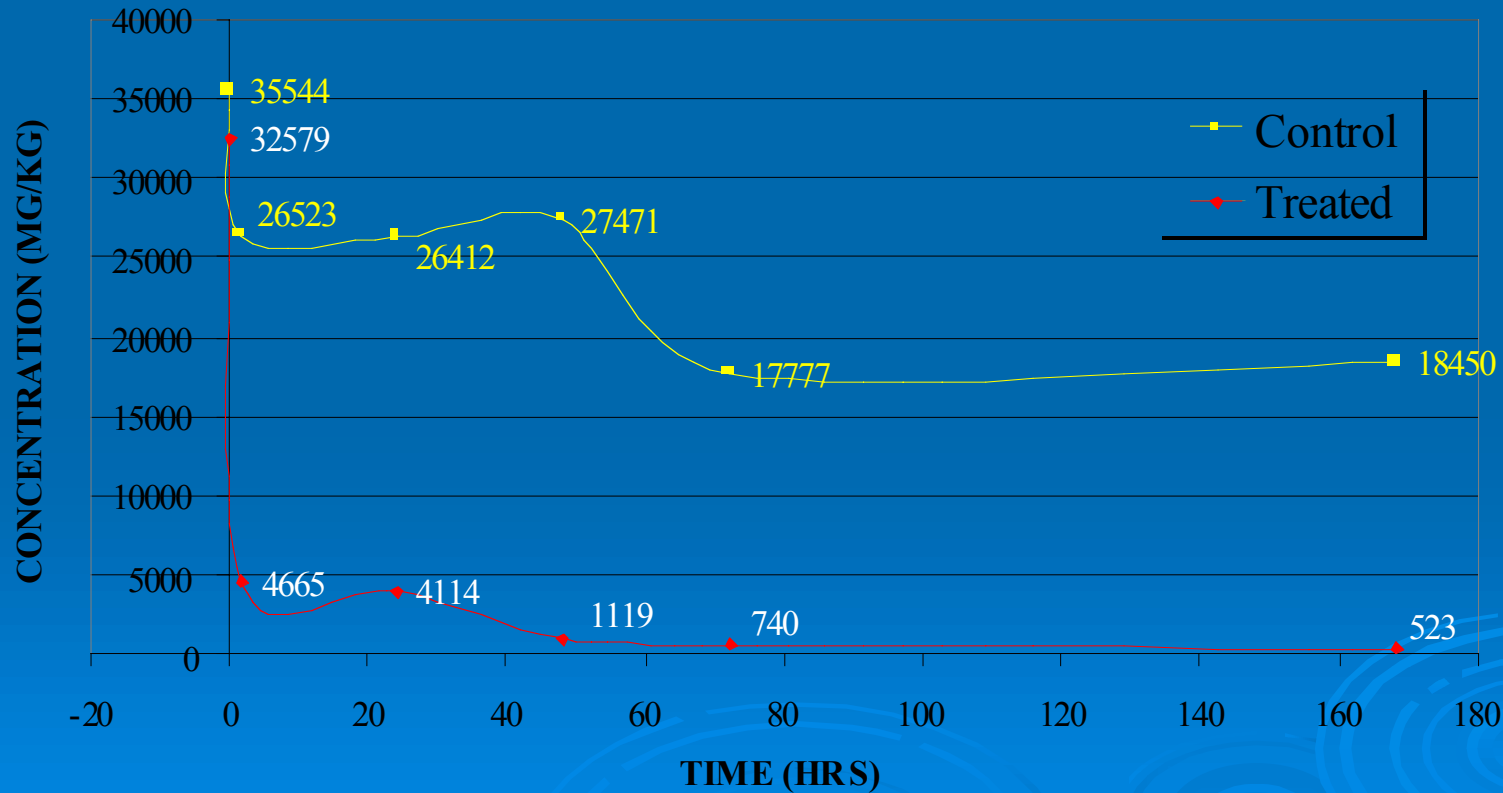


CS 1 Control Cell Reduction

Time	GC	S.A.	MC	Contaminant	Mass
	FID	Volume	Wt	Mass	Reduction
hrs	mg/kg	x initial	%	kg	%
0	35544	1	14.9	41.0	0.00
1.5	26523	1.3	20.7	41.0	0.00
24	26412	1.3	16.8	41.0	0.00
48	27471	1.3	15.4	41.0	0.00
72	17777	1.3	15.4	26.6	35.1
168	18450	1.3	11.4	26.6	35.1

CS 1 PHC Concentration Reduction-Treated

PHC DEGRADATION



CS 1 Treated Cell Reduction

Time	GC	S.A.	MC	Contaminant	Mass
	FID	Volume	Wt	Mass	Reduction
hrs	mg/kg	x initial	%	kg	%
0	32579	1	13.3	37.6	0.00
1.5	4665	1.25	21.0	6.7	82.2
24	4114	1.32	18.1	6.3	83.2
48	1119	1.32	19.5	1.7	95.4
72	740	2	18.2	1.7	95.4
168	523	2	16.1	1.2	96.8

CS1 Performance Summary

PHC Concentration Reduction: 32,579 mg/kg to 523 mg/kg

96% Contaminant Mass Reduction In Treated Cell

35% Contaminant Mass Reduction In Control Cell

61% Greater Reduction Than Control Cell

CASE STUDY 2

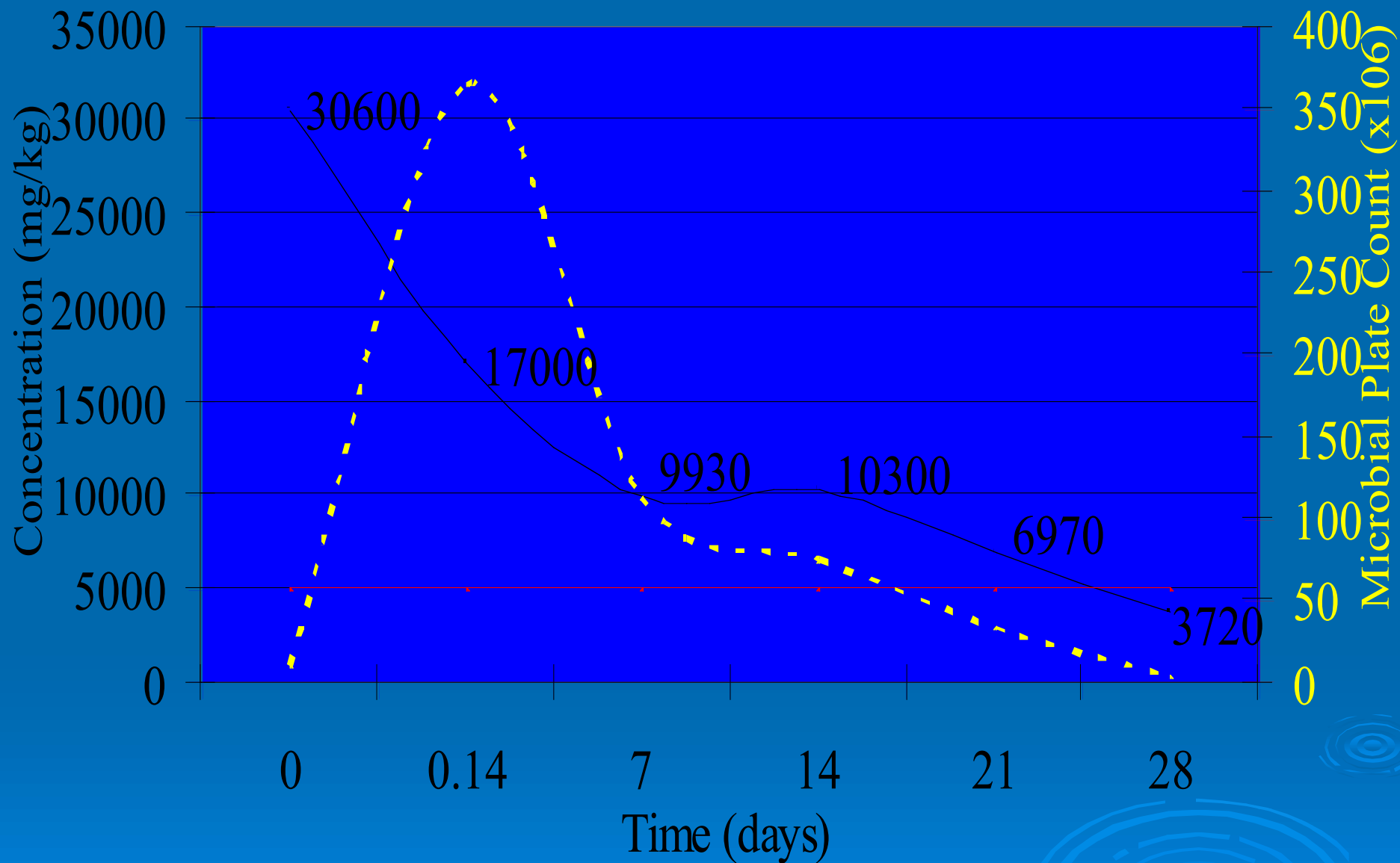
Abandoned Oilfield Drill Site

After Two Years of Composting
Contaminant Levels Reached Apparent
Asymptotic Limits

Contaminant – Oil-Based Drill Cuttings
Initial PHC Concentrations - 30,600 mg/kg

CS 2 Operating Parameters

Parameter	Value
Mixing Frequency	Weekly
Moisture Content (treatment zone)	18 - 31 % by weight
pH (treatment zone)	7.1-7.6
Residence Time	28 days
Temperature	Ambient



CS 2 PHC Degradation

CS 2 Dilution Effect

Media	Vol. m ³	Density kg/m ³	Conc. mg/kg	Weight kg
DC	120	1200	30600	144000
SA	40	1500	0	60000

Concentration Reduction Due to Dilution

160

21600

204000

CS 2 Performance Data

Sample ID	Hydrocarbon (mg/kg)	Plate Count (cfu/gm)	Moisture Content
Waste-Initial	30,600	10 x10 ⁶	31%
3.5 hrs	17,000	365 x10 ⁶	---
7days	9,930	112 x10 ⁶	---
14 days	10,300	---	24%
21 days	6,970	33 x10 ⁶	---
28 days	3,720	3 x 10 ⁶	18%

CS2 Performance Summary

PHC Concentration Reduction **30,600 mg/kg**
to **3,720 mg/kg** In 28 Days

26% Initial Reduction In Contaminant Mass

Total Reduction Based on Tilling Practices

62% Min. Contaminant Mass Reduction

84% Max. Contaminant Mass Reduction



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