Large scale Bioremediation of hydrocarbon contaminated sites in desert environment

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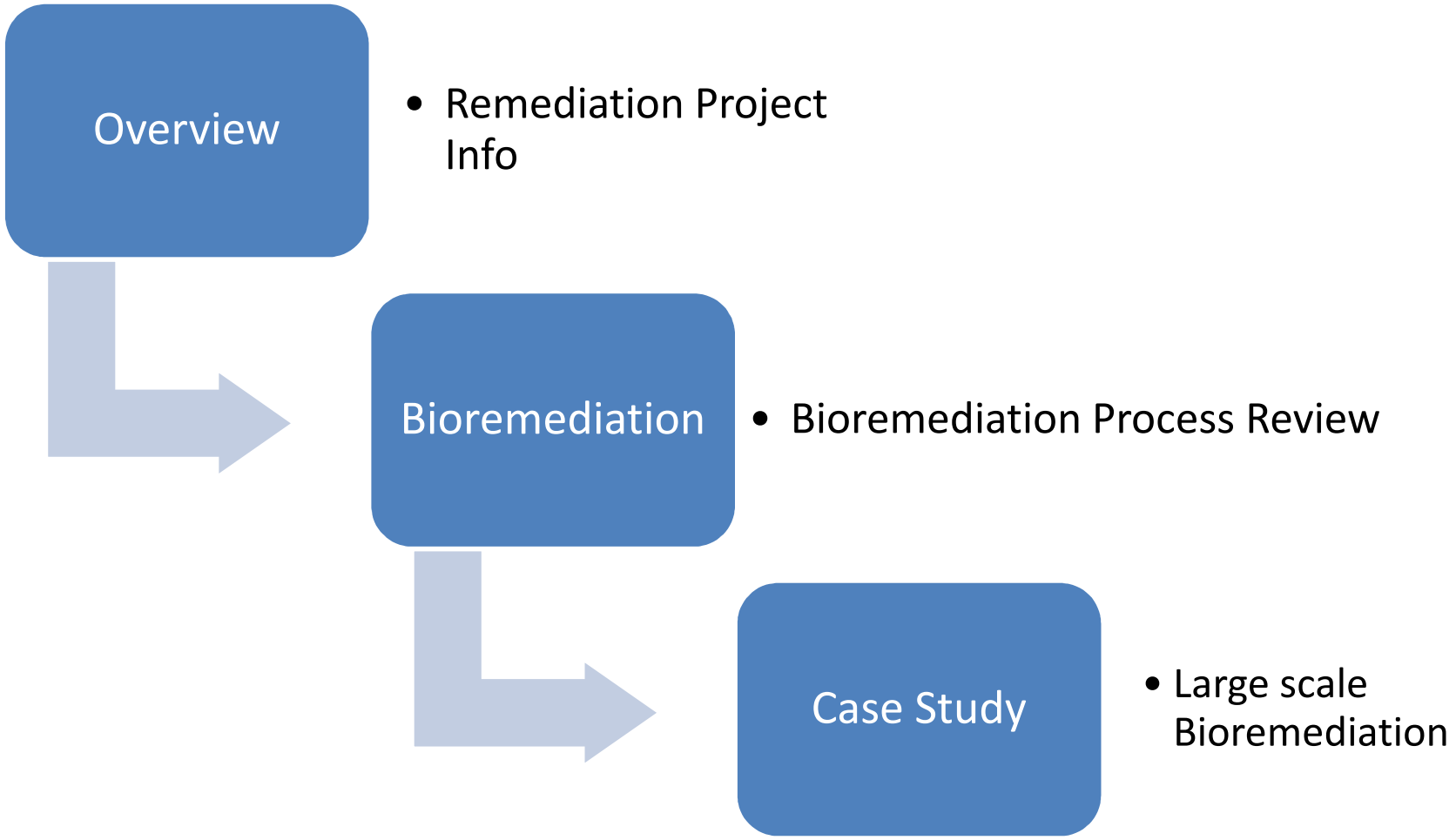
Presentation Outline

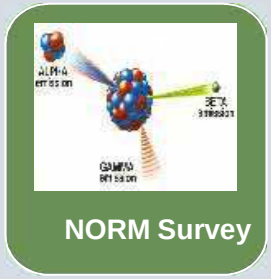


SEED (Sustainable Environmental & Economical Development) Project

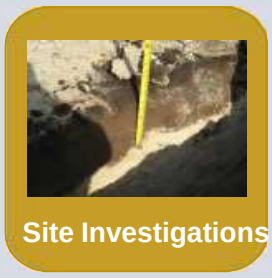
- Undertake an assessment of the land degradation caused by historical oil and gas exploration and production activities in KOC.

- Remediate & Rehabilitate the contaminated features exist with the company (Phase wise)


EOD/UXO



NORM Survey


Site Investigations


Oil Recovery


Remediation


Rehabilitation

CONTAMINATED FEATURES

Effluent Pit

Effluent Pit

Effluent Pit

Gatch Pit

Sludge Pit

Contaminated Soil Pile

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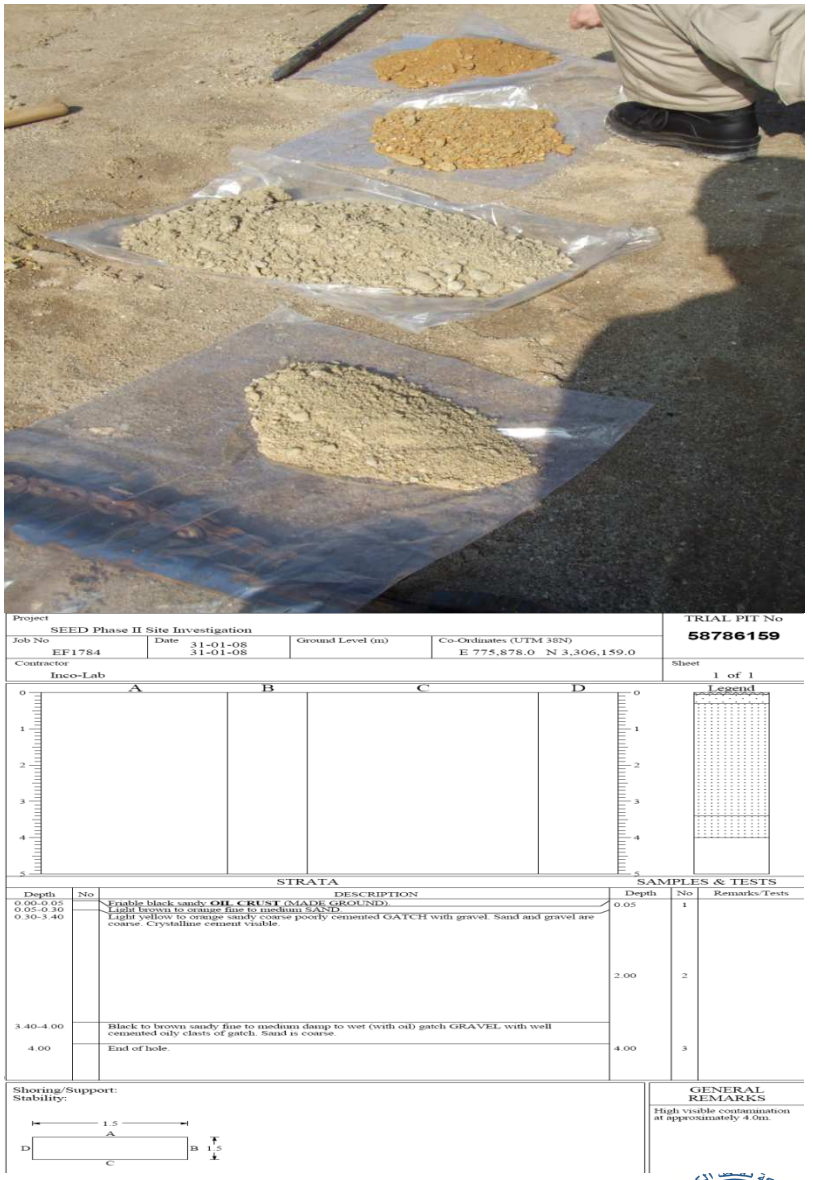
Kuwait Oil Company
إحدى شركات مؤسسة البترول الكويتية
A Subsidiary of Kuwait Petroleum Corporation

Contaminants of Concern

- Petroleum Hydrocarbons (PH – Carbon banded)
- Polycyclic Aromatic Hydrocarbons (PAH – total and speciated)
- Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)
- Heavy Metals
- Inorgnics & General
  - Sulphate
  - Chloride
  - Cyanide
  - Phenols
  - Nitrogen, Phosphorus and Potassium
  - pH and
  - Conductivity.



Project: SEED Phase II Site Investigation | TRIAL PIT No: 58786159

Job No: EF1784 | Date: 31-01-08 31-01-08 | Ground Level (m) | Co-Ordinates (UTM 38N): E 775,878.0 N 3,306,159.0

Contractor: Inco-Lab | Sheet: 1 of 1

Legend

Depth	No	STRATA DESCRIPTION	Depth	No	SAMPLES & TESTS Remarks/Tests
0.00-0.05		Engine black sandy OIL CRUST (MADE GROUND)	0.05	1	
0.05-0.30		Light brown to orange fine to medium SAND.			
0.30-3.40		Light yellow to orange sandy coarse poorly cemented GATCH with gravel. Sand and gravel are coarse. Crystalline cement visible.	2.00	2	
3.40-4.00		Black to brown sandy fine to medium damp to wet (with oil) gatch GRAVEL with well cemented oily clasts of gatch. Sand is coarse.			
4.00		End of hole.	4.00	3	

Shoring/Support:
Stability:

GENERAL REMARKS
High visible contamination at approximately 4.0m.

Site situation/Setting

- **Harsh climate (0-58 ^{0}C)**
- **High Wind speeds**
  - Sand storms
  - Sand erosions

- **Unfavorable Characterization**
- Heavier fractions/Ashphaltin
- (TPH- HEM : 4% & TPH – SEM : 11-13%)
- Detailed Characterization
- Limited pilots/demo studies

REMEDIATION SPECIFICATION

Primary Ecotoxic RS

Applicable to material within top 1.5m below finished grade;
- Total PHC ≤ 5,580 mg/kg;
- PAHs compound specific; and

Application of amendments as required to achieve ecological function.

Alternative Ecotoxic RS

Applicable to material within top 1.5m below finished grade;
- Total PHC ≤ 10,000 mg/kg;
- Salinity (SAR <4); and

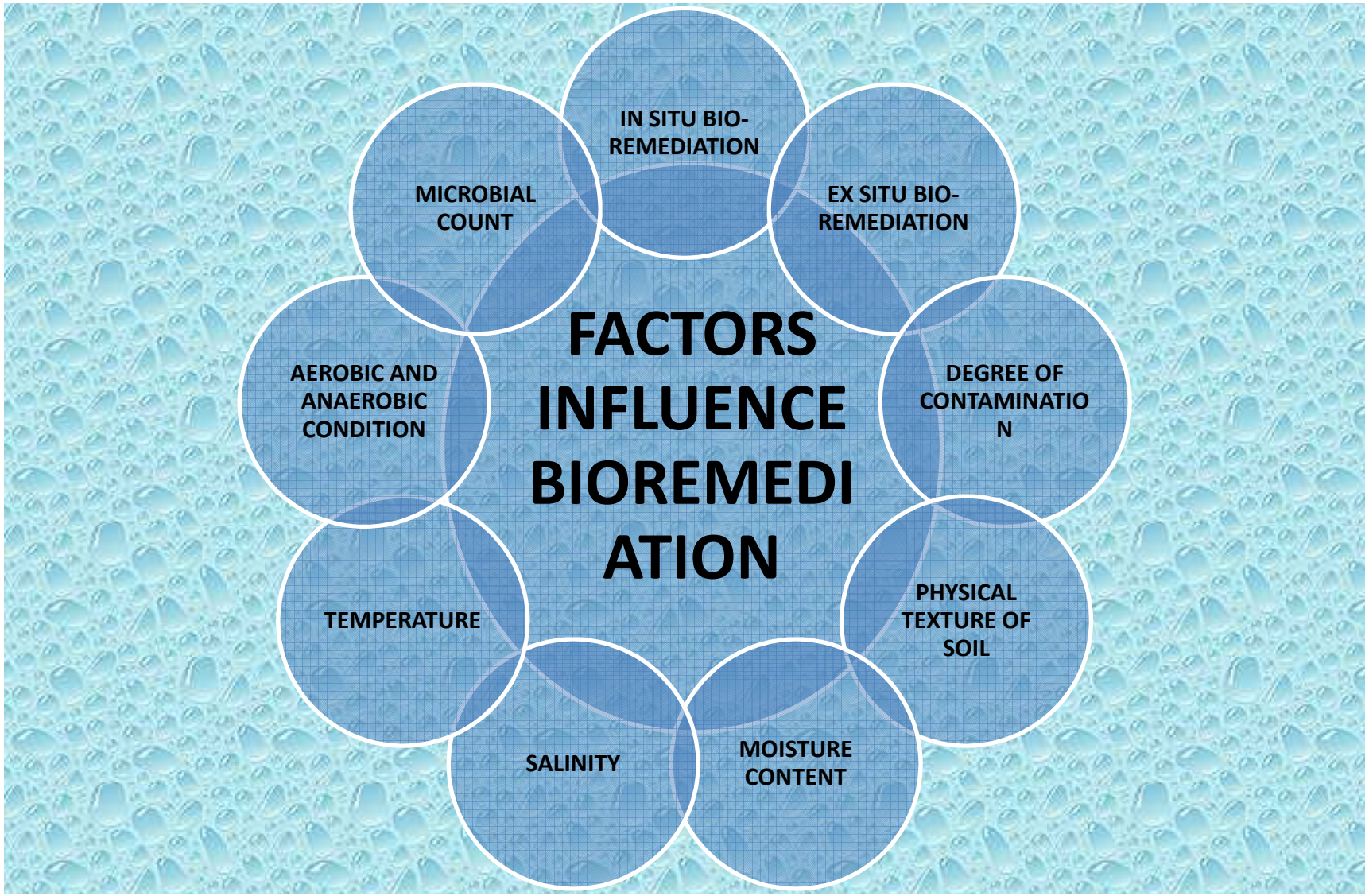
Application of amendments as required to achieve ecological function.

Commercial / Industrial RS

Applicable to material below 1.5m of finished grade;
- Total PHC ≤ 30,000 mg/kg; and
- PAHs compound specific.

Bioremediation (BR) & Factors influencing BR

BR: Using microorganisms to transform hazardous contaminants into relatively harmless byproducts, such as carbon dioxide and water

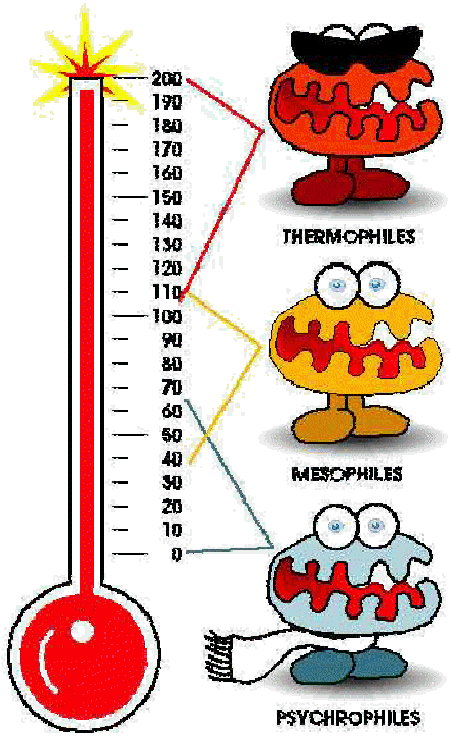


Types of Bioremediation

- Natural Attenuation
- Aerobic/Anaerobic biodegradation
- Biopiles
- Land Treatment
- Bioscrubbers
- Methanotrophic Process (in Situ)
- Plant Root Uptake (Phytoremediation)
- Solid Phase Bioremediation
- Bio Wall for Plume Decontamination (In Situ)

Why Bioremediation

- Low cost compared to mechanical treatment systems
- No additional disposal costs
- No maintenance issues
- Does not create an eyesore
- Good for planting



Advantages and Disadvantages

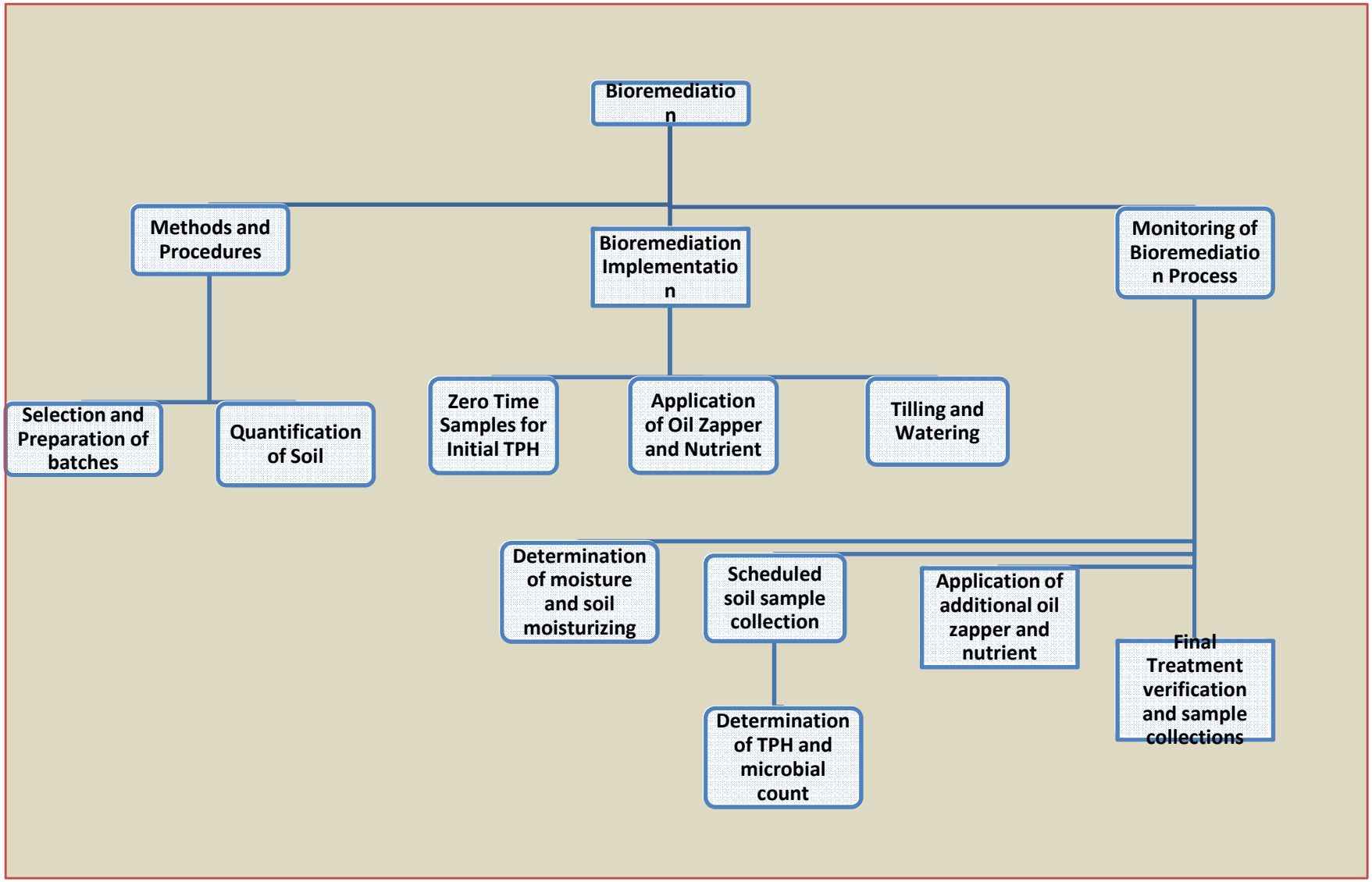
Method	Advantages	Disadvantages
• **In situ Bio**	• Excavation of soils and transportation can be avoided • Backfilling can be avoided • Cost effective	• Presence of oily/sludge lumps • Difficalty in delineation contamination due to undulances • Possibilities of dilution

Method	Advantages	Disadvantages
• **Ex situ Bio**	• Oily/sludge lumps can be seived prior to bio remediation • Dilution from bottom of the soils can controlled	• Possibilities of dilution while soil excavation due to uneven contamination trend • Expensive compare to In situ • Contruction of bio pad is required to control dilution and lechate infiltration.

Regular Bioremediation activities

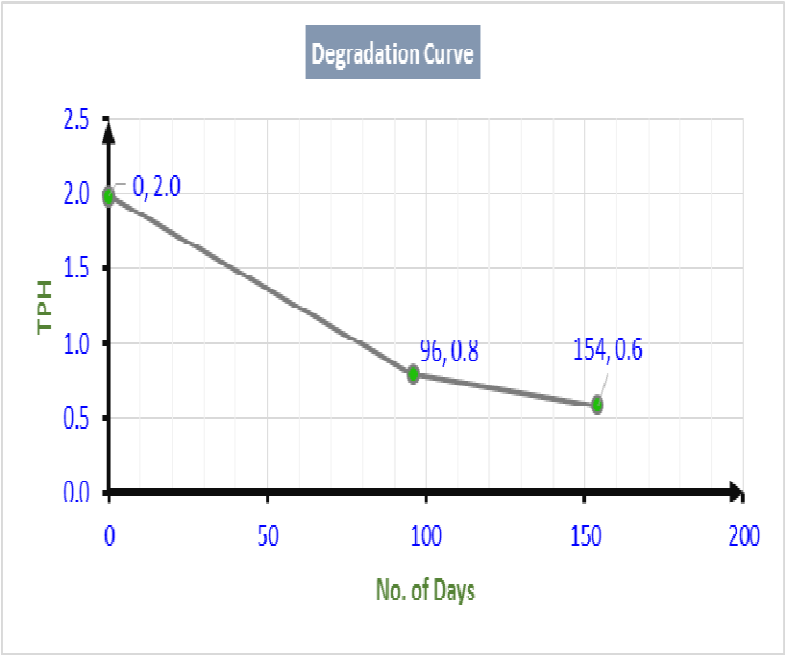
Initial TPH analysis	Before application of oil zapper
• Zero Day Sampling	
Soil Moisturizing	If Soil moisture is less than 10%
• 10-15% has to maintain	
Soil moisture check	Weekly
• For internal laboratory analysis	
Soil Tilling	Bi Weekly
• Tractor and/or Excavator	
TPH analysis and Microbe count	For internal laboratory analysis
• Monthly	
Oil zapper and Nutrient application	Initially 5 Kg oil zapper applied for 1 m^3 soil.
• If microbe count is less than $1x10^5$ CFU	

Bioremediation – Implementation Plan



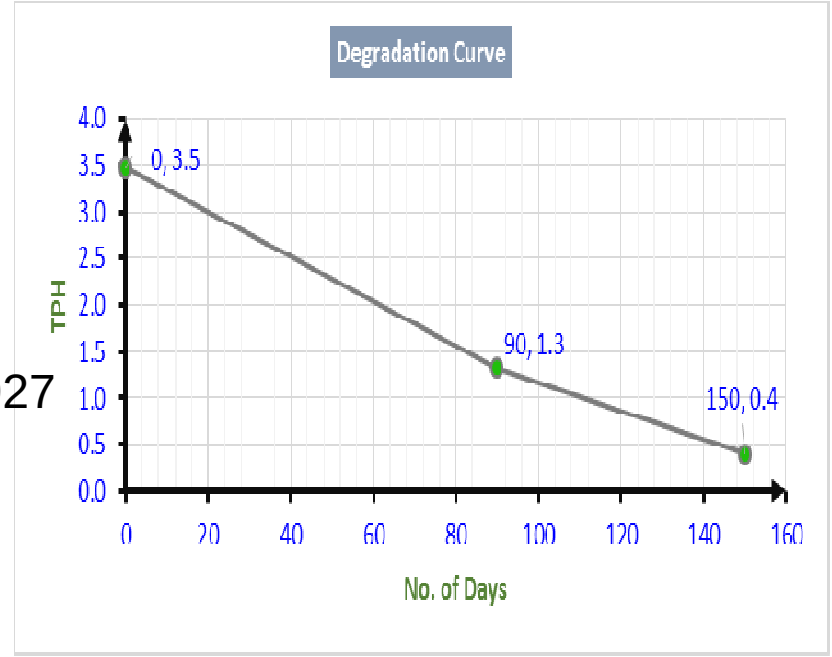
Case study 1 : Decommissioned Effluent Pit - Batch 1

- Quantity of Soil (m3) : 2,750
- Bio Pad Dimensions(meter) : 79.5x68.5x0.51 (LxBxH)
- Initial TPH (Mg/Kg) : 19,875
- Target Remediation (Mg/Kg) : 10,000
- Post Remediation TPH (Mg/Kg) : 7,600
- Total Qty of Oil Zapper applied (Kgs) : 43,848
- Total Qty of Nutrient applied (Kgs) : 3,100
- Qty of Water Added (gallons) : 1,42,000
- Avg. Moisture (%) : 16.2
- Avg. Microbe count(CFU) : $1*10^{6.5}$
- Number of Days for completion : 154 days



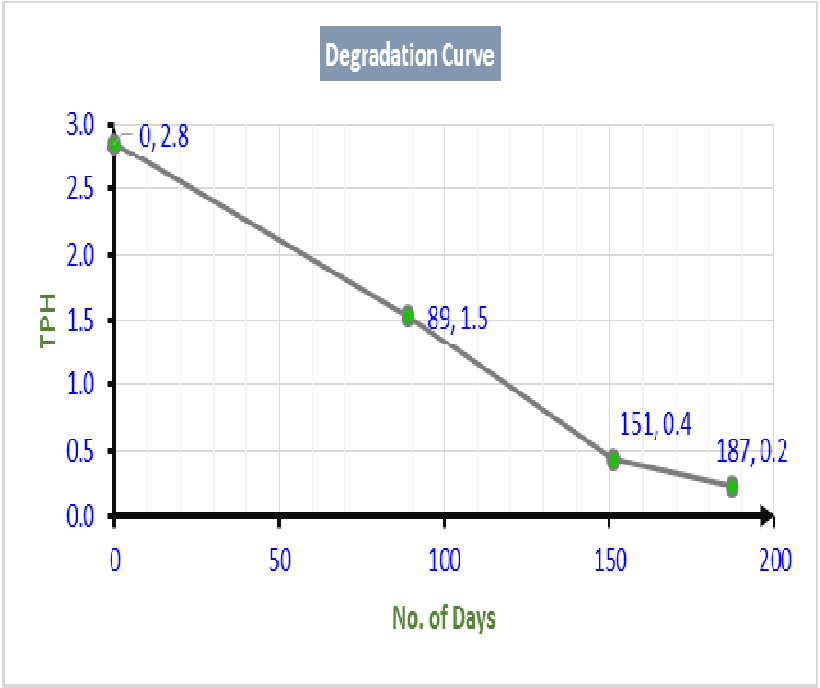
Case study 2 : Decommissioned Effluent Pit - Batch 2

- Quantity of Soil (m3) : 10,518
- Bio Pad Dimensions(meter) : 0.2-1.0 (H)
- Initial TPH (Mg/Kg) : 20,909
- Target Remediation (Mg/Kg) : 10,000
- Post Remediation TPH (Mg/Kg) : 3,996
- Total Qty of Oil Zapper applied (Kgs) : 75,927
- Total Qty of Nutrient applied (Kgs) : 6,017
- Qty of Water Added (gallons) : 1,337,000
- Avg. Moisture (%) : 16.4
- Avg. Microbe count(CFU) : $1*10^{4.75}$
- Number of Days for completion : 151 days



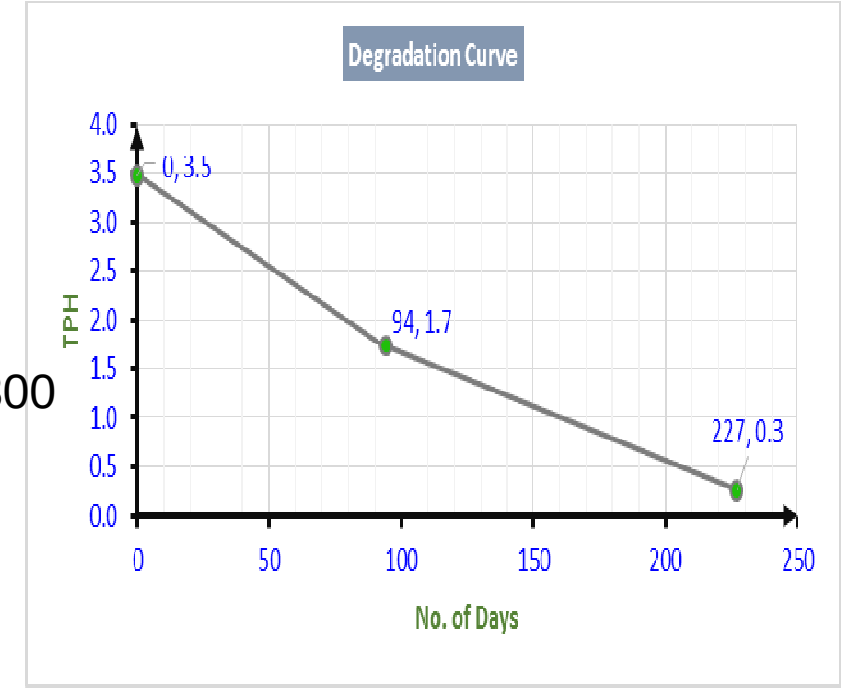
Case study 3 : Decommissioned Effluent Pit - Batch 3

- Quantity of Soil (m3) : 2,220
- Bio Pad Dimensions(meter) : 120x38.5x0.48 (LxBxH)
- Initial TPH (Mg/Kg) : 28,450
- Target Remediation (Mg/Kg) : 5,883
- Post Remediation TPH (Mg/Kg) : 2,310
- Total Qty of Oil Zapper applied (Kgs) : 13,500
- Total Qty of Nutrient applied (Kgs) : 700
- Qty of Water Added (gallons) : 90,000
- Avg. Moisture (%) : 17.2
- Avg. Microbe count(CFU) : $1*10^{6.6}$
- Number of Days for completion : 186 days



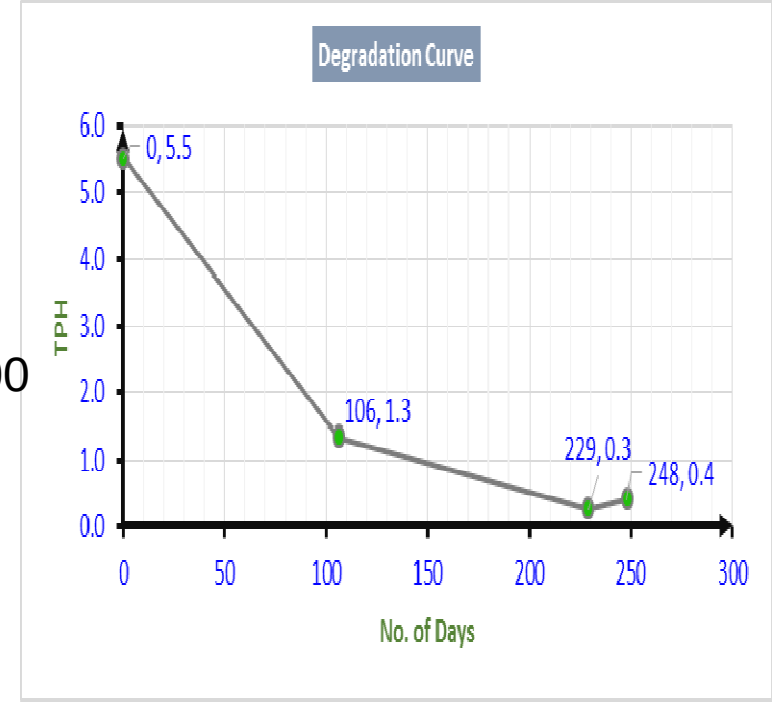
Case study 4 : Decommissioned Effluent Pit - Batch 4

- Quantity of Soil (m3) : 1,389
- Bio Pad Dimensions(meter) : 78x35x0.5 (LxBxH)
- Initial TPH (Mg/Kg) : 34,700
- Target Remediation (Mg/Kg) : 5,883
- Post Remediation TPH (Mg/Kg) : 2700
- Total Qty of Oil Zapper applied (Kgs) : 9,800
- Total Qty of Nutrient applied (Kgs) : 227
- Qty of Water Added (gallons) : 92,000
- Avg. Moisture (%) : 14.7
- Avg. Microbe count(CFU) : $1*10^{5.7}$
- Number of Days for completion : 239 days

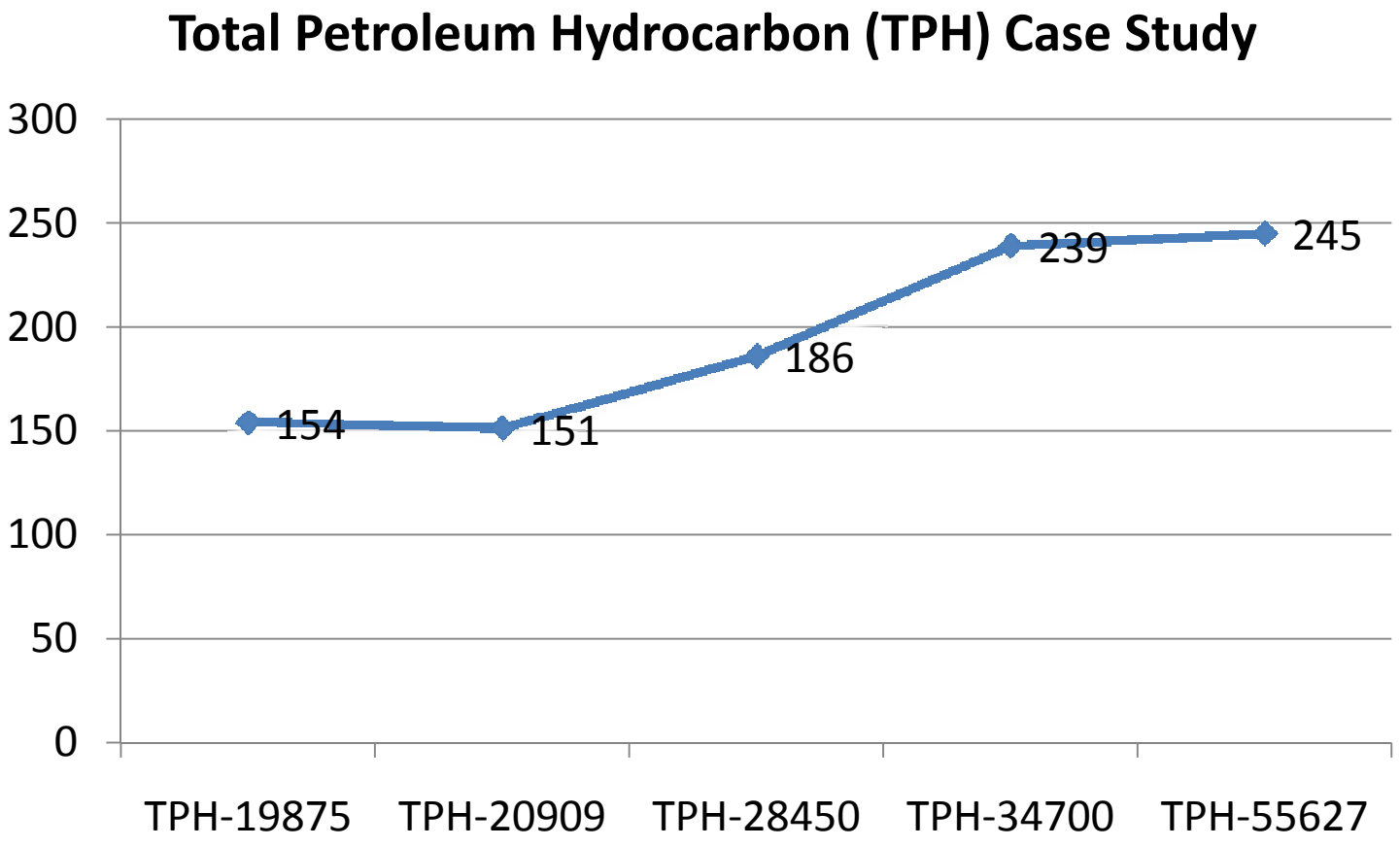


Case study 5 : Decommissioned Effluent Pit - Batch 5

- Quantity of Soil (m3) : 1,708
- Bio Pad Dimensions(meter) : 80x42.5x0.5 (LxBxH)
- Initial TPH (Mg/Kg) : 55,267
- Target Remediation (Mg/Kg) : 5,883
- Post Remediation TPH (Mg/Kg) : 2,676.6
- Total Qty of Oil Zapper applied (Kgs) : 16,700
- Total Qty of Nutrient applied (Kgs) : 800
- Qty of Water Added (gallons) : 1,08,000
- Avg. Moisture (%) : 14.3
- Avg. Microbe count(CFU) : $1*10^{6.1}$
- Number of Days for completion : 245 days



Case Study : Results



SEQUENCE OF BIO REMEDIATION ACTIVITIES – FIELD PICS

Survey for soil quantification

Oil Zapper application

Soil Moisturizing

On site Moisture Check & lab Oven for moisture analysis

Tilling with Tractor and Excavator

Soil samples collection

Samples composition and lab analysis

BIO REM SOIL TEXTURE VARIATION

Zero day - Soil colour and Texture

11th day - Soil colour and Texture

28th day - Soil colour and Texture

39th day - Soil colour and Texture

55th day - Soil colour and Texture

77th day - Soil colour and Texture

91th day - Soil colour and Texture

101st day - Soil colour and Texture

117th day - Soil colour and Texture

127th day - Soil colour and Texture

151th day - Soil colour and Texture

After Remediation

Alu Bucket for Sieving

Alu bucked segregated lumps and pebbels

Piles after lumps separated manually

Limitations of bio remediation

PHYSICAL TEXTURE OF SOIL	• Oily/Sludge Lumps can be remediated
HIGH TPH	• TPH Greater than 7% has no significant degradation
SALINITY	• Salinity has not reduced at any remediated soil
TIME DURATION	• Moderate contaminated soils undergo minimum 210 days
POSSIBILITIES OF DILUTION	• At Large scale remediation sites construction of concrete or HDPE surface for bio pad is not practical, tilling activities likely to significant dilution.
AREA REQUIREMENTS	• As bio pads of higher depth can not perform well, bio soils to be spread as minimum as possible
UMBER SAMPLES TO BE ANALYZED AT THIRD PARTY LAB	• To Monitor the Degradation trend intermediate samples to be analyzed at third party labs
WATER REQUIREMENTS	• Substantial quantity of water to be used for soil moisturizing

Bioremediation Caste Study - Outcome

- Excavated and successfully bio-remediated in excess of 18000 m3 of soil over two seasons. Overall more than 80,000 m3 of soil bioremediated.
- Achieved ecotoxic/alternate standards for all soils treated on site – Typically with 5 months and above.
- Soils treated/aerated using Allu bucket. Allowed aggressive mixing and aeration.
- Only additives were diammonium phosphate and water. Hence geotechnical properties of soils preserved.
- Fugitive emissions (odour and dust) managed via well implemented environmental management plan.

Large Scale Bioremediation Case Study

Thank you

Q&A