Bioremediation of Oil Contaminated Soil in Kuwait

Obayashi Corporation

Burning by Destruction of Oil Wells

provided by KOC

Burning by Destruction of Oil Wells

Oil Lake

Oil Lake (an Aerial Photo)

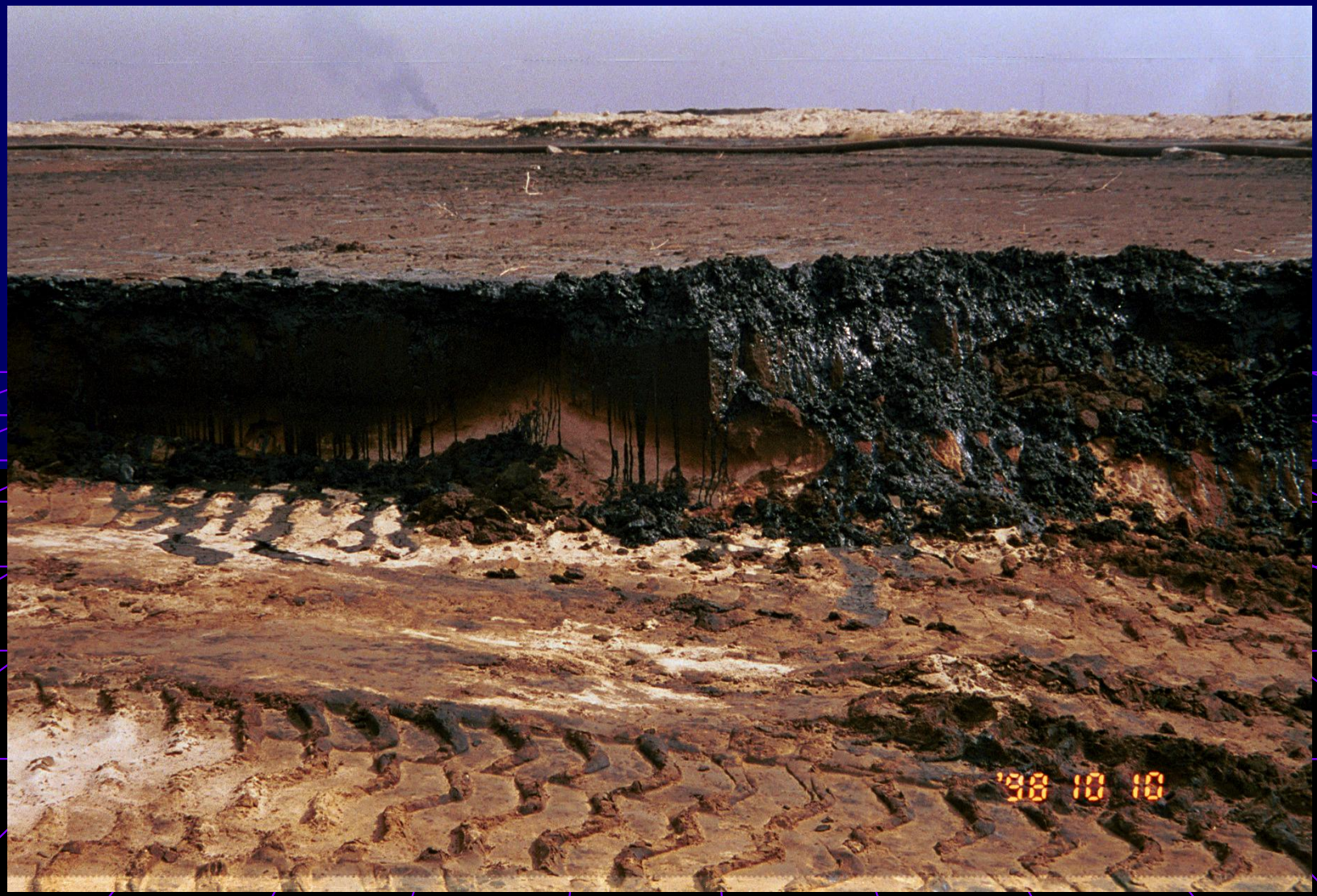
Oil Lake

Damage to the Dates Palm

Oil Lake No.102

Removal of Oil Sludge

Example of Oil Contaminated Soil



Weather of Kuwait

Burgan Oil Field

Organization of the Project

1994 - 1999

Kuwait Oil Company

Ministry of International Trading and Industry

Collaboration

Supervise

Kuwait Institute for Scientific Research

Food Resources Division

Petroleum Energy Center

International Collaboration Department

Collaboration

Entrust

Entrust

Entrust

Bio-remediation

Physical and Chemical Treatment

Coordination

Obayashi Corporation

Collaboration

Bio-industry Association

University of Tokyo

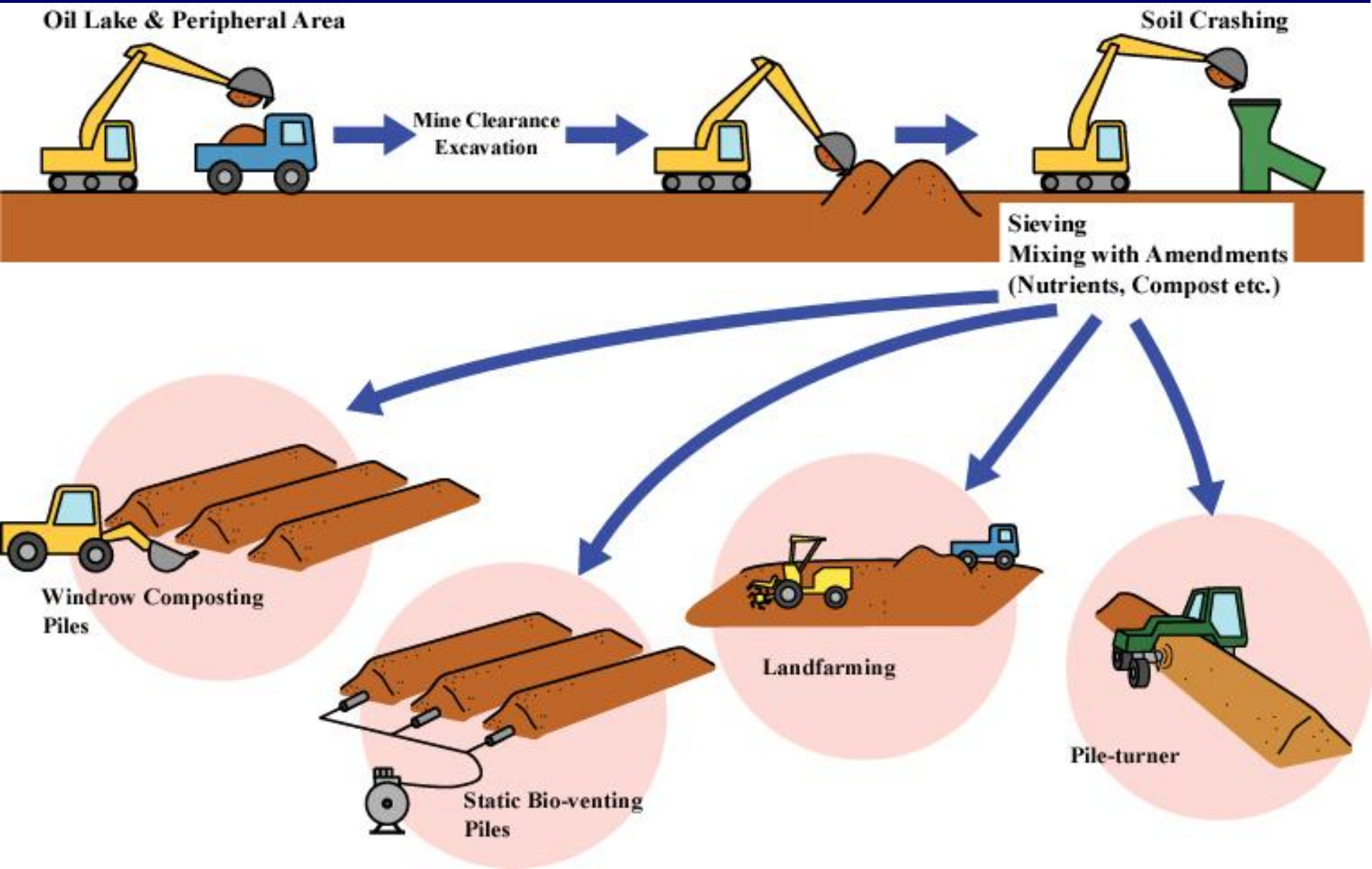
Shimizu Corporation

Arabian Oil Company

Mine Removal by MOD

Excavation of the Oil Contaminated Soil

Introduction of 4 Technologies

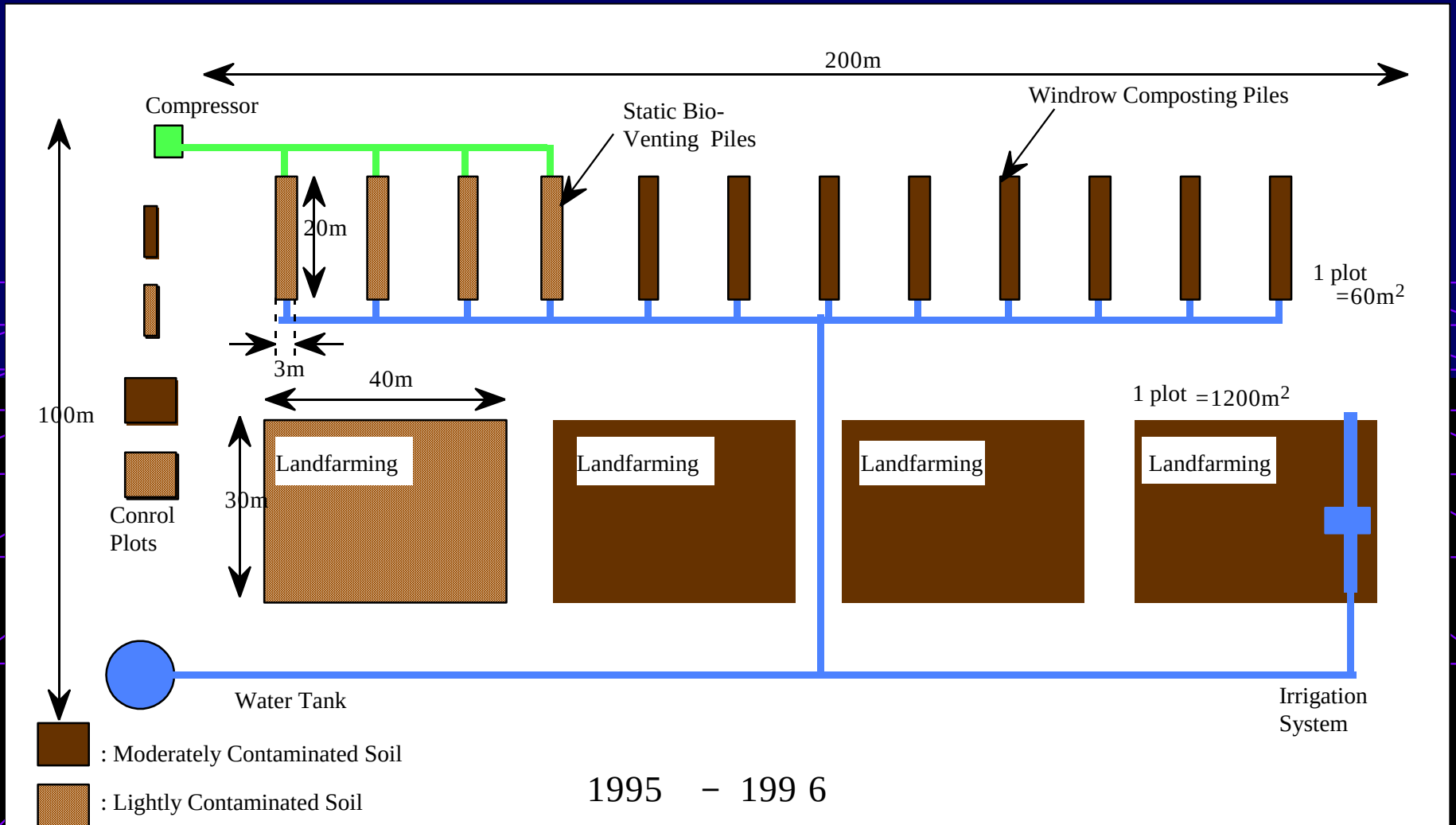


Bioremediation

Treatment method of microorganisms

- Biostimulation : Activation of native degrading microorganisms by adding nutrient and air etc.
- Bioaugmentation : Inoculation of selected efficient microorganisms into contaminated water and soil
- Remediation of contaminated underground water and soil using bioreacter

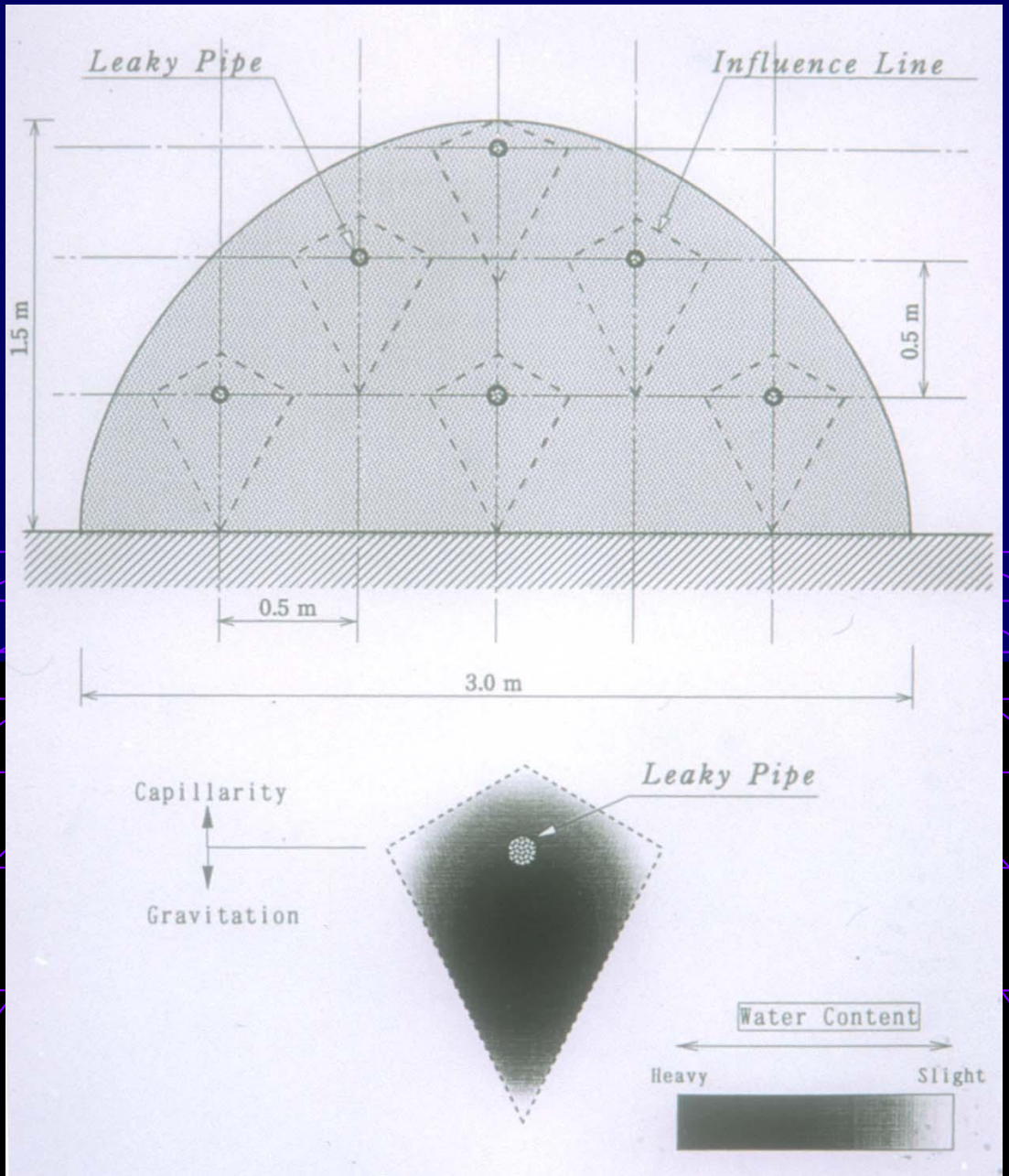
Landfarming Plots, Windrow Composting Piles and Static Bio-venting Piles



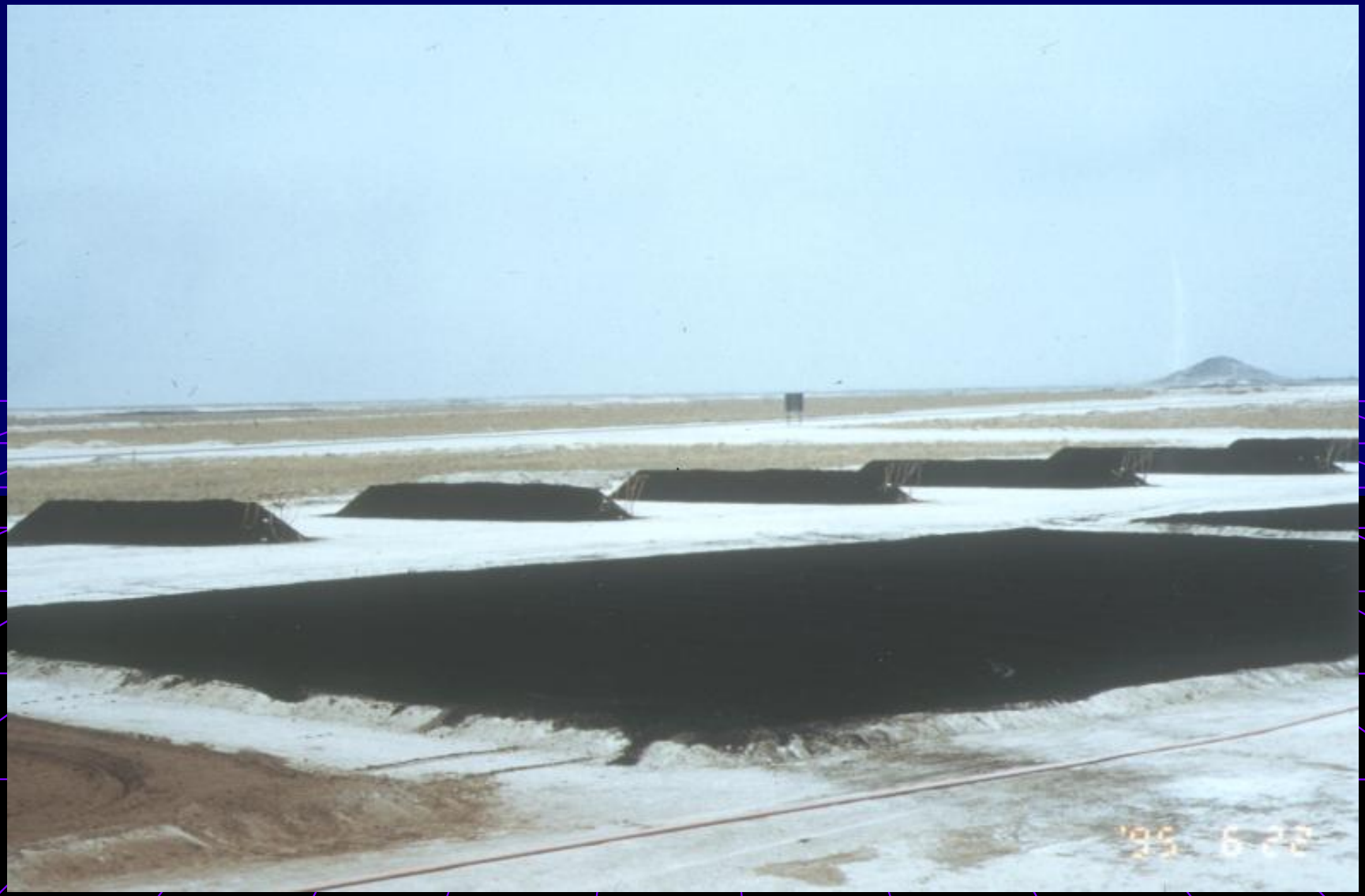
Maintenance of Landfarming

Maintenance of Landfarming

Cross Section in the Window Soil Pile

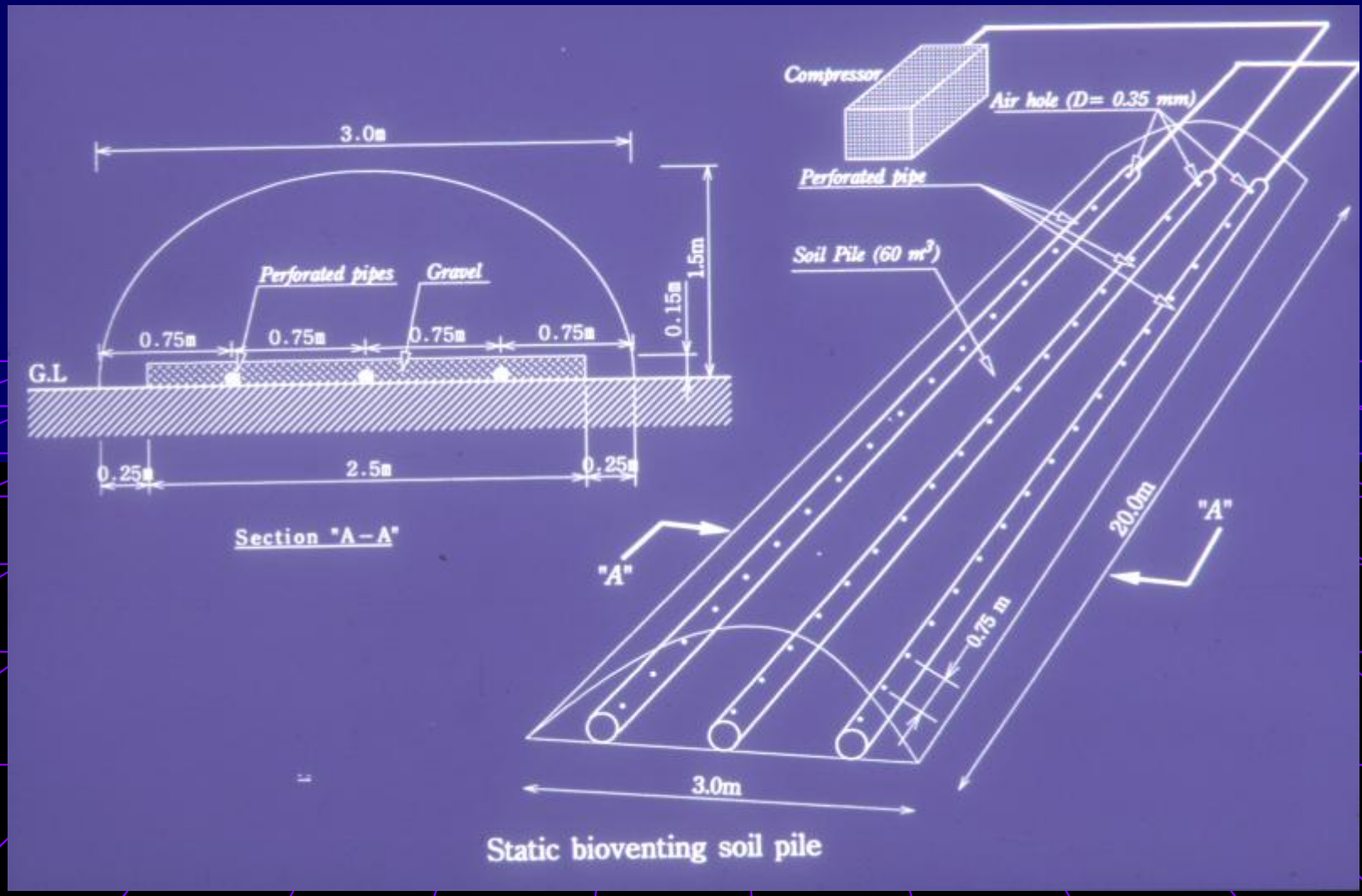


Soil Piles and Landfarming Plots



Maintenance of Windrow Composting Piles

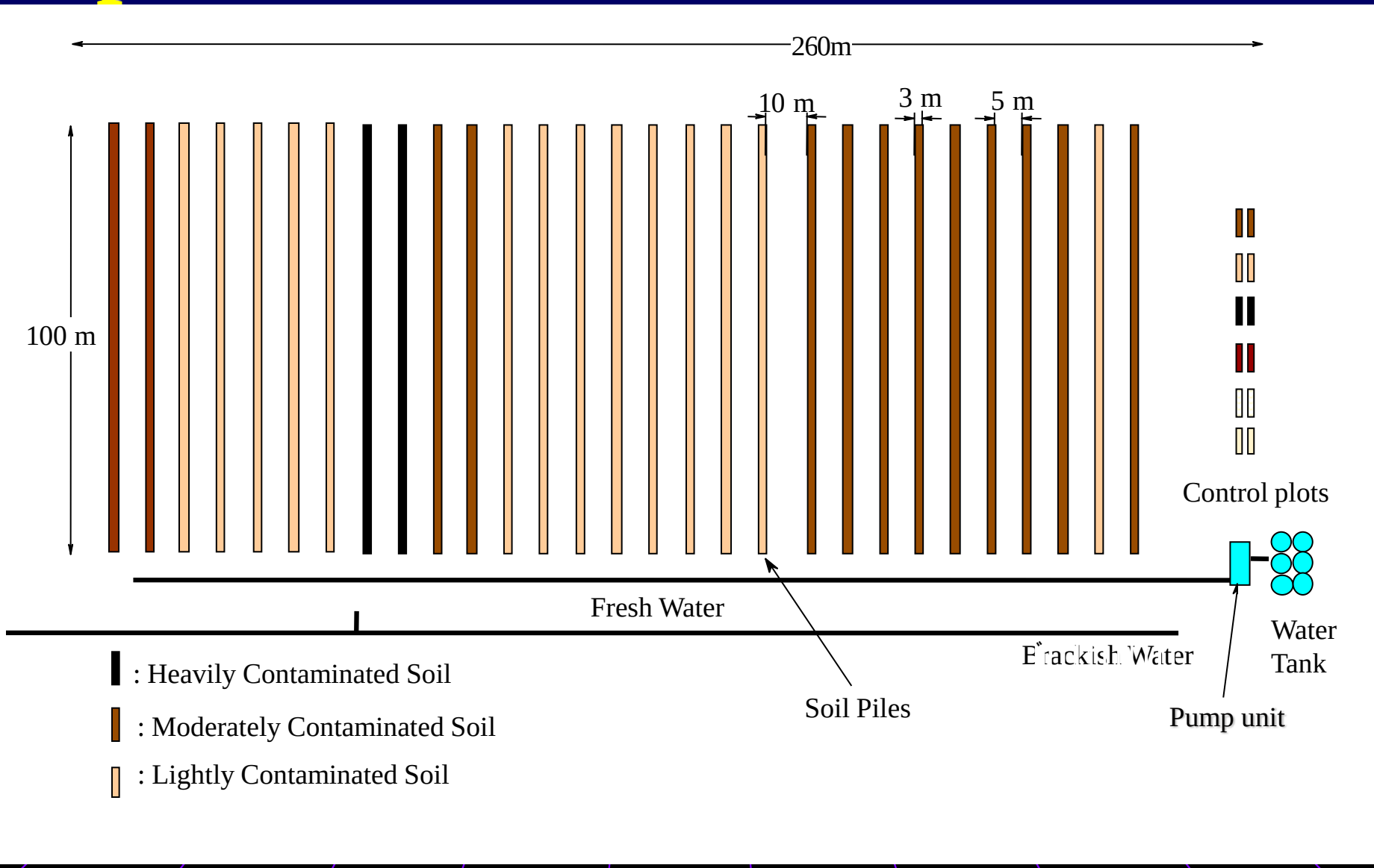
Concept of Static Bio-venting Soil Pile



Construction of a Big Static Bio-venting Pile

Compressor for the Static Bio-venting Piles

Layout of Pile Turner Experiment



Area for Pile Turner Method

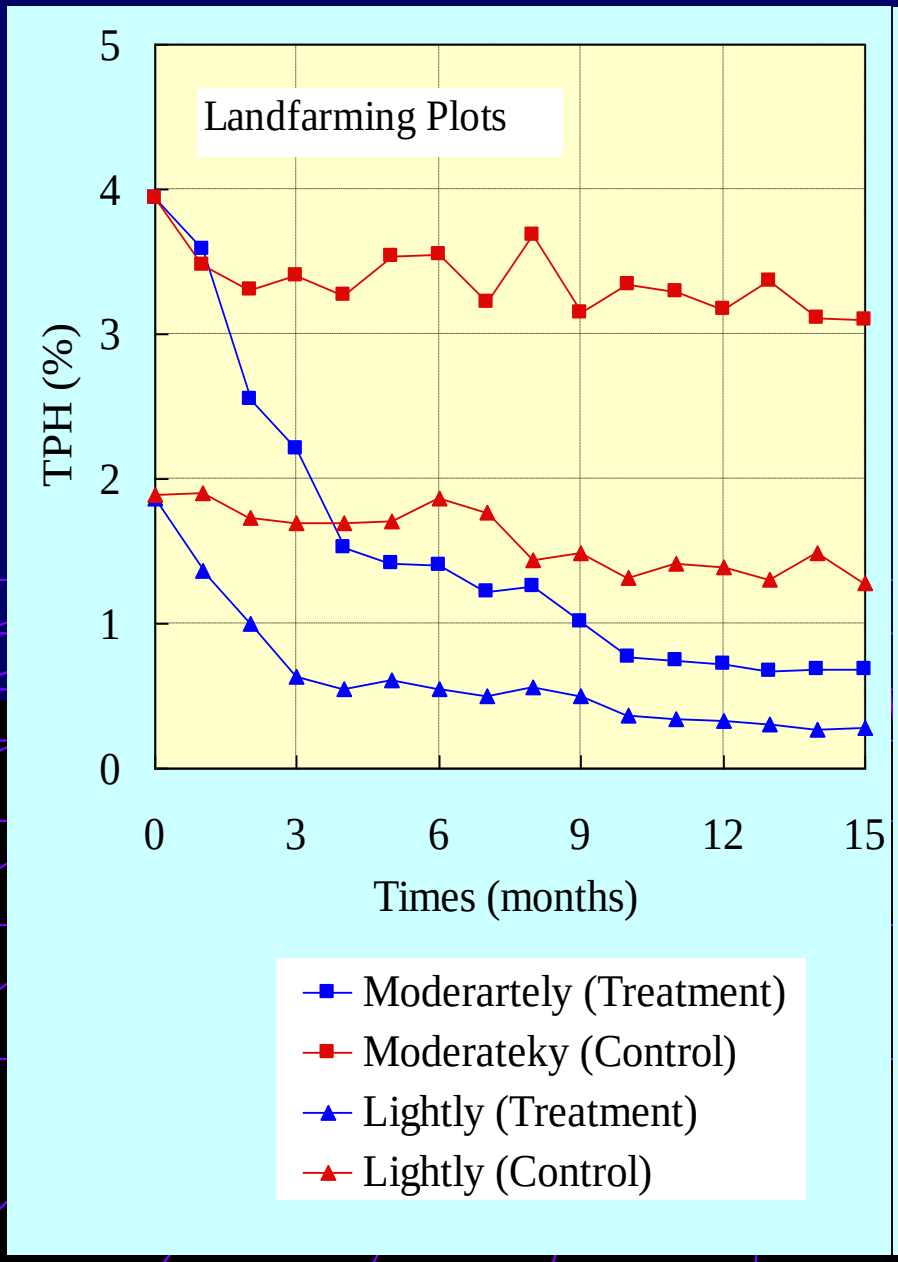
Mixing with Soil and Amendments

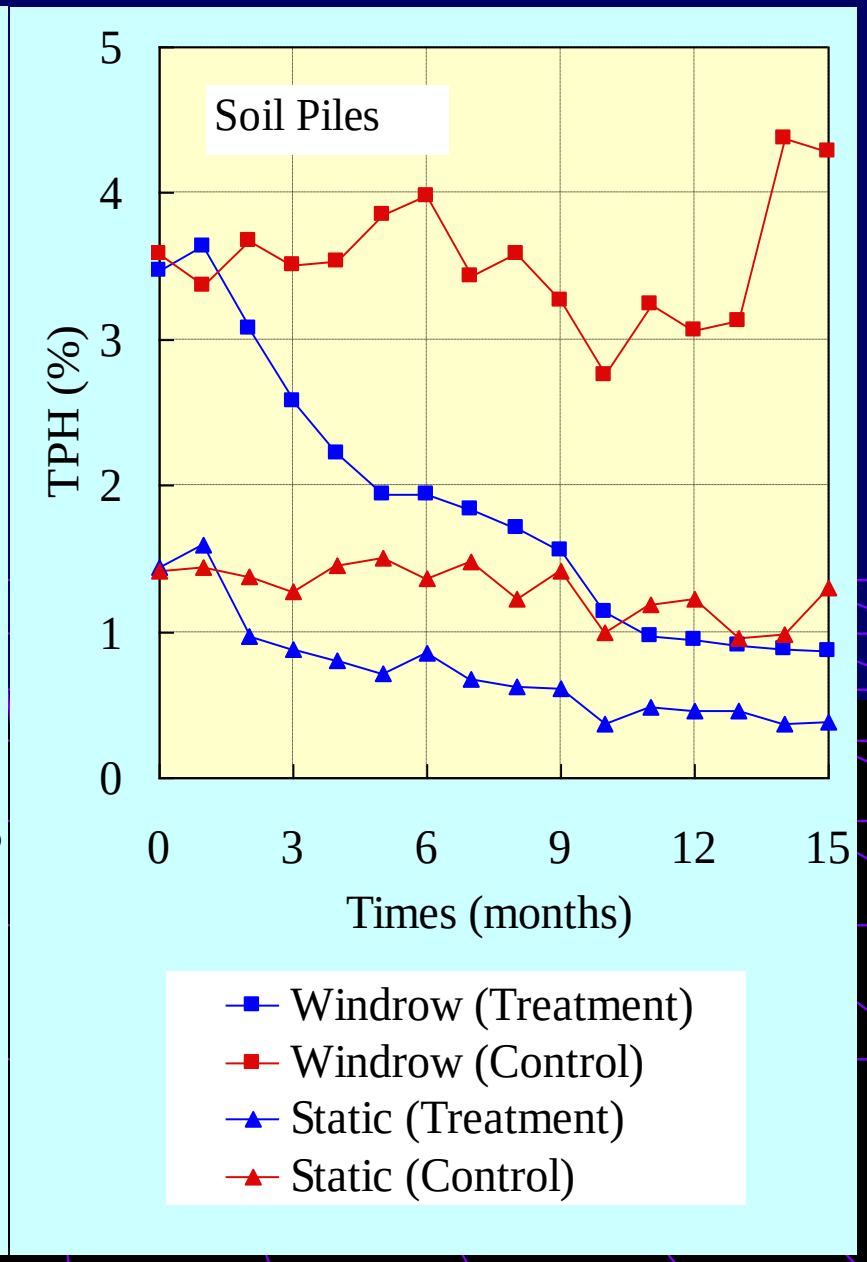
The Blade of Pile Turner

Soil Characteristics

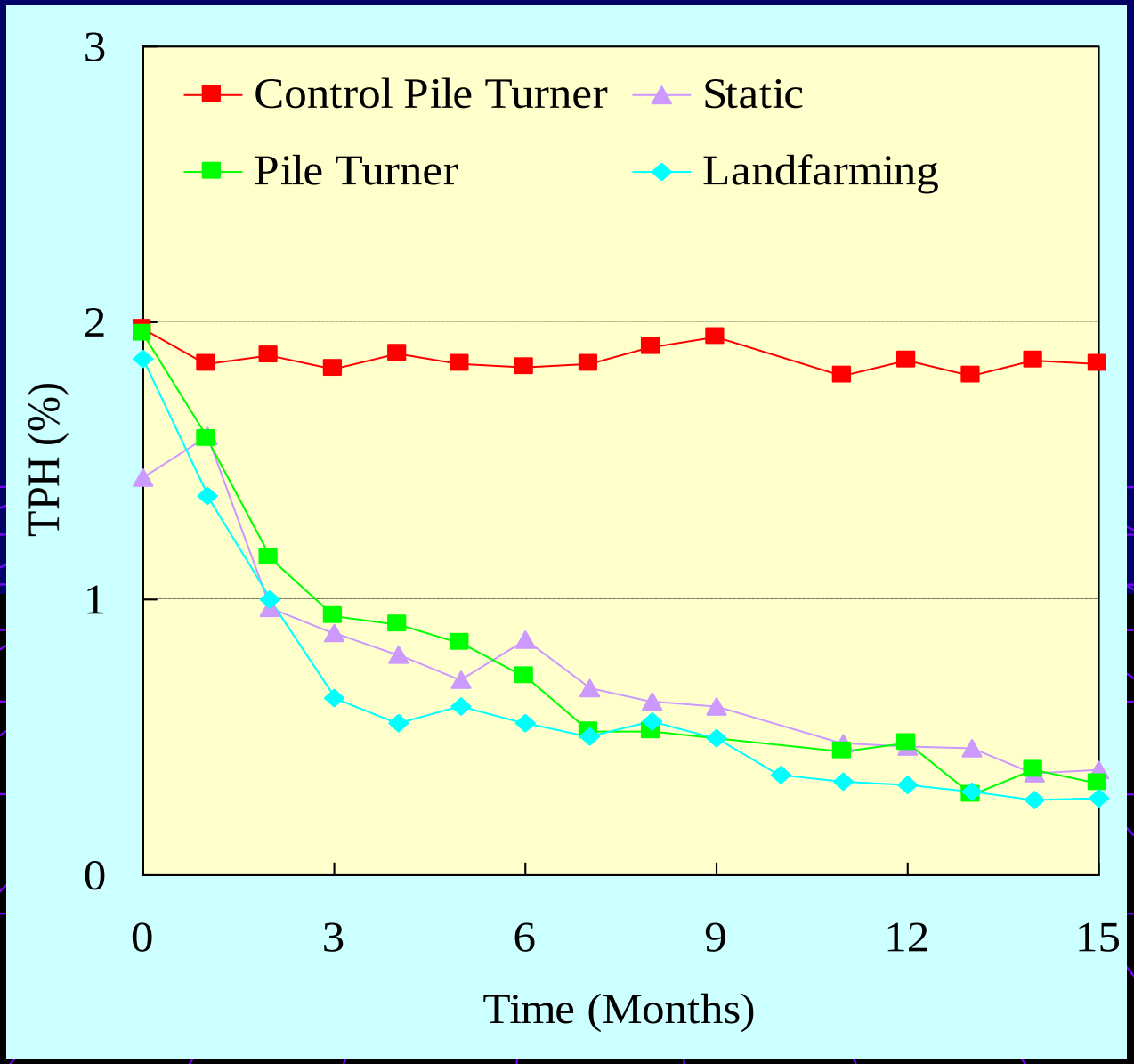
Item	unit	Lightly Contaminated Soil	Moderately Contaminated Soil
pH		8.0	7.9
EC	mS/m	560-690	1420-4450
Moisture Content	%	0.5	2
Conbustible Matter	%	4.5	9.1
TPH	%	1.9-2.0	3.3-4.0
Total Bacterial Count	Log cfu/g	6	6

Result of TPH Analysis

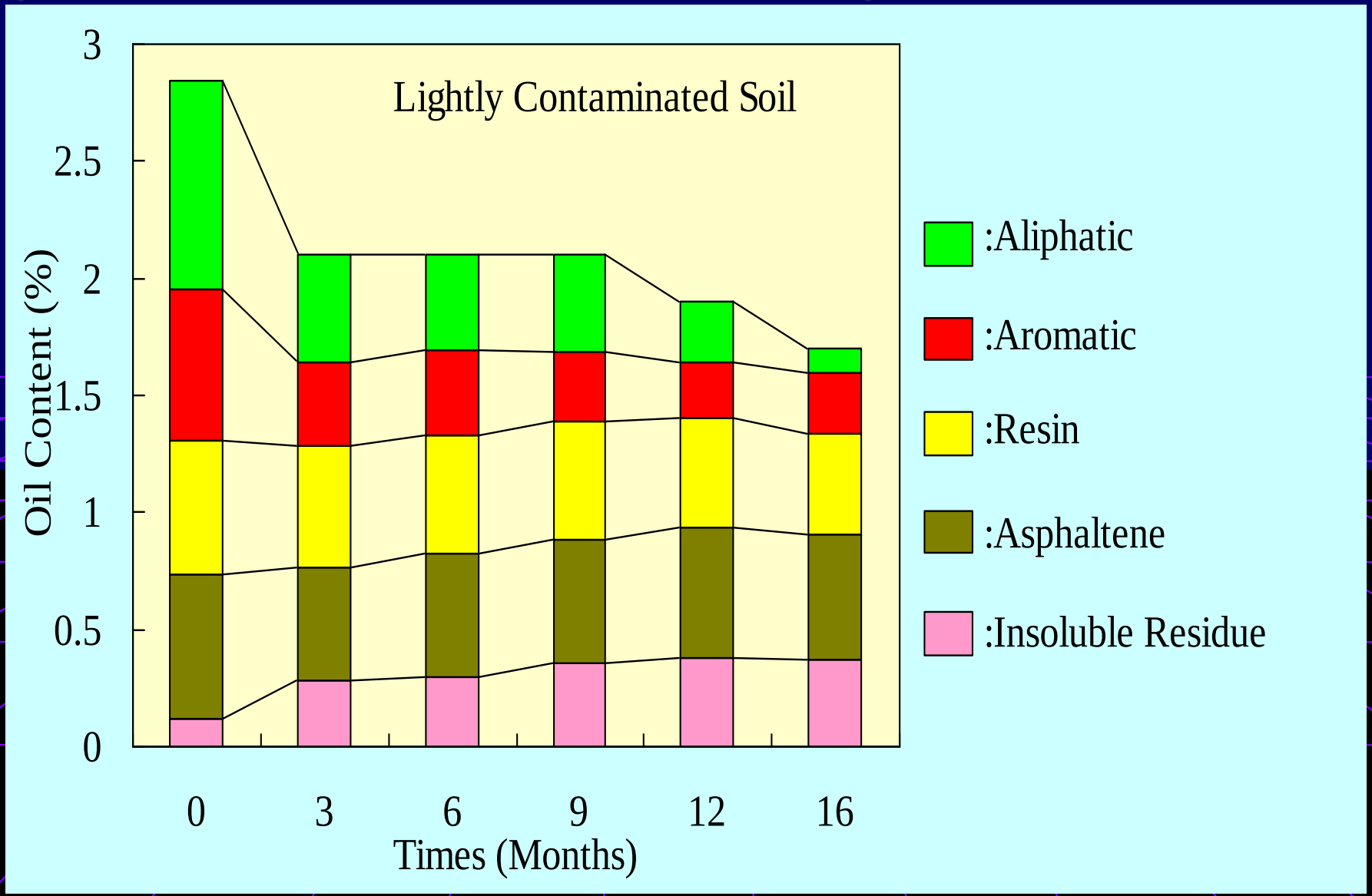




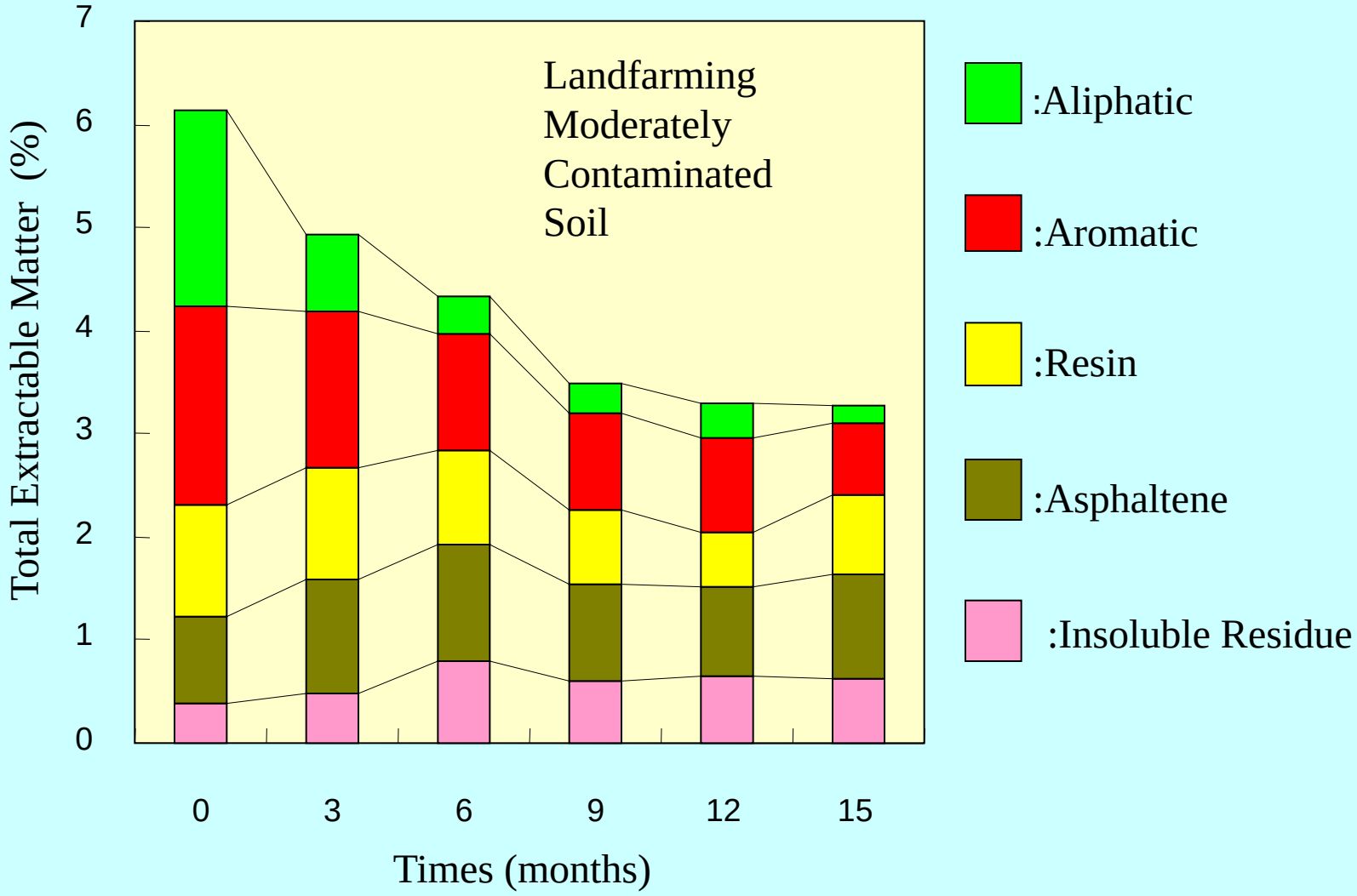
Result of TPH (Part 2)



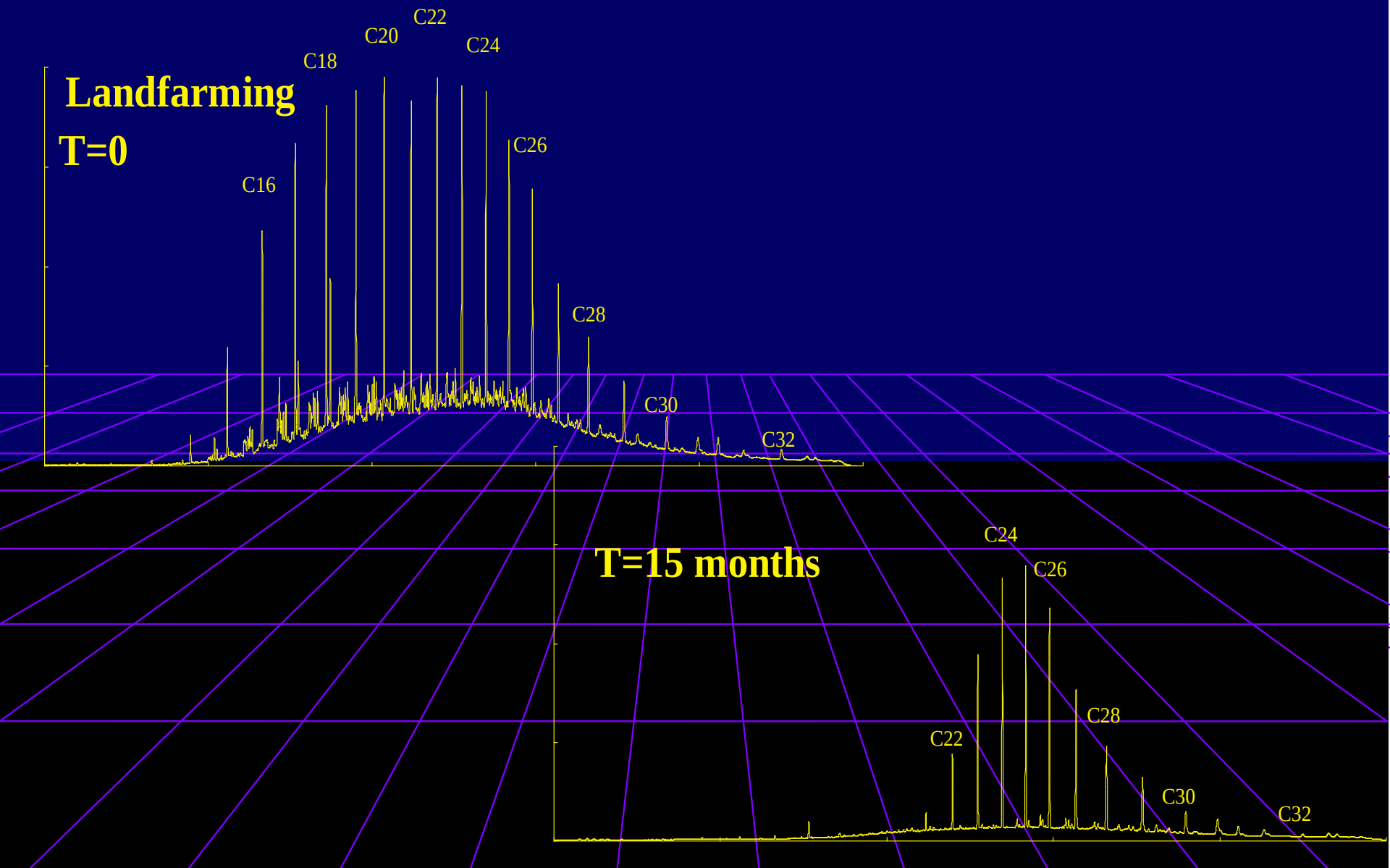
Fraction Analysis (Pile Turner Method)



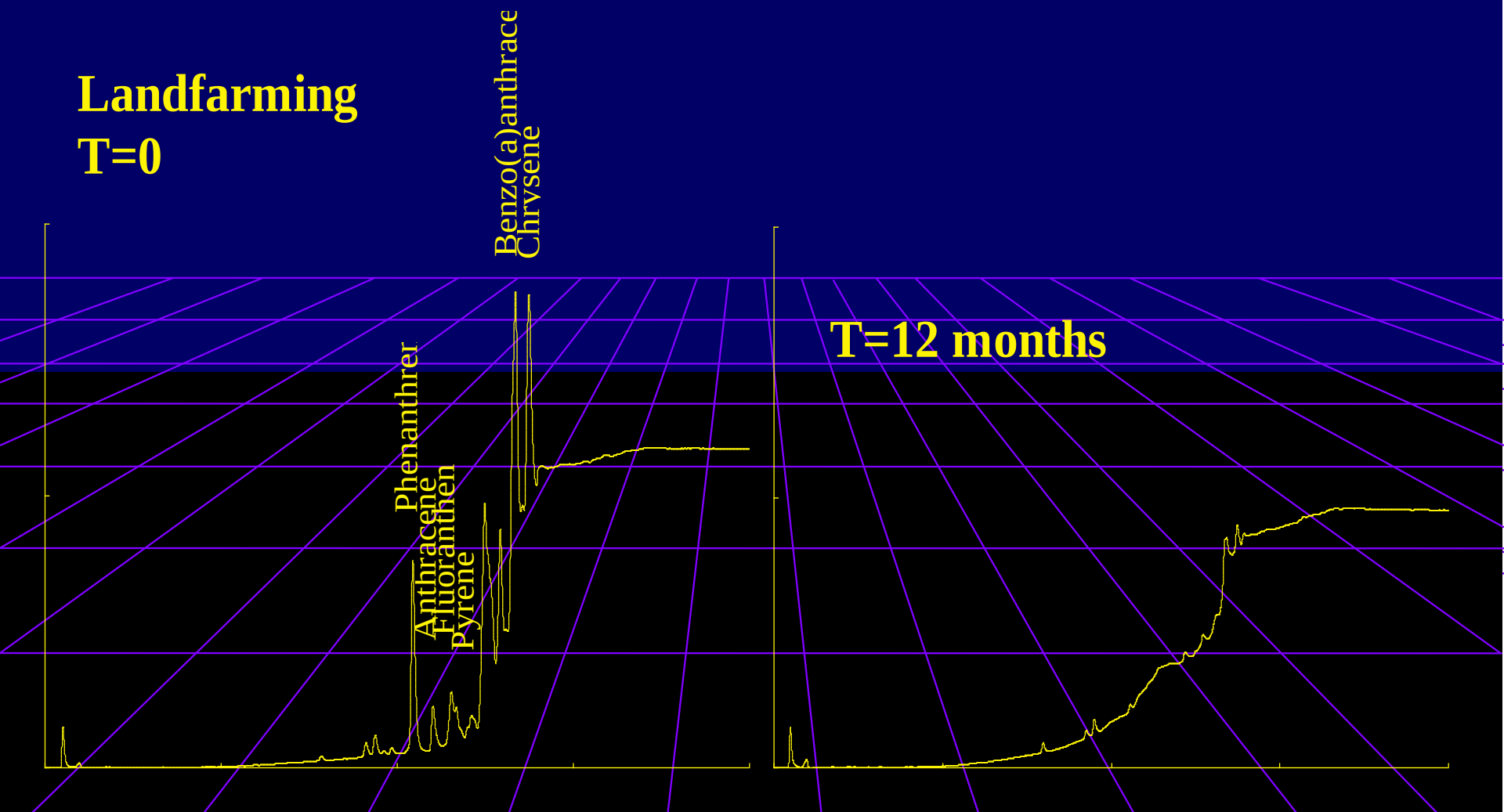
Result of Fraction Analysis (Landfarming)



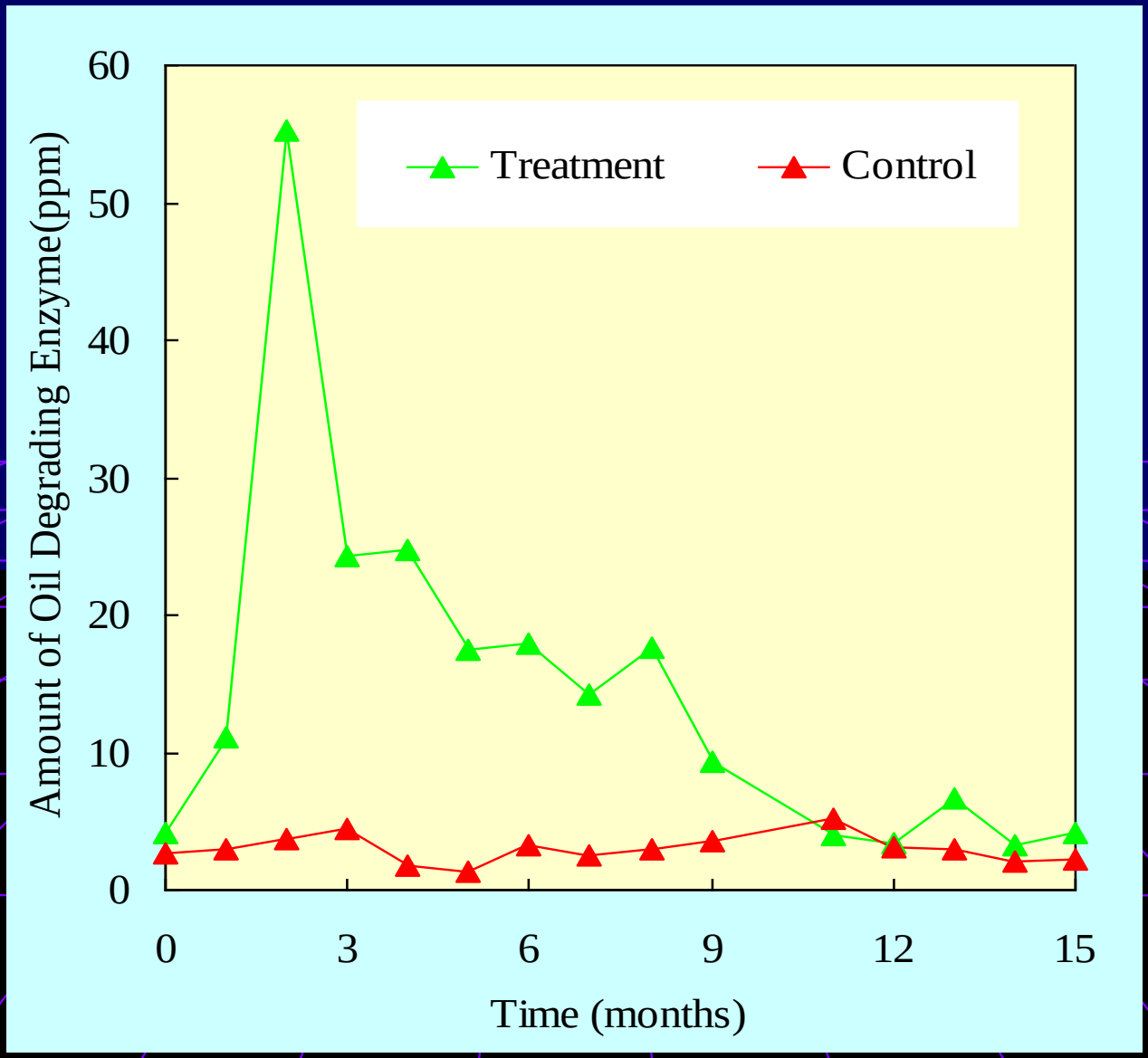
Result of Gas Chromatograph



Result of PAH Analysis



Microbial Activity



Ames Test (Mutagenicity Test)

- One of the toxicity test
- Analysed each 3 months
- After 3 months treatment, mutagen had been degraded

Result of Mutagenicity Test

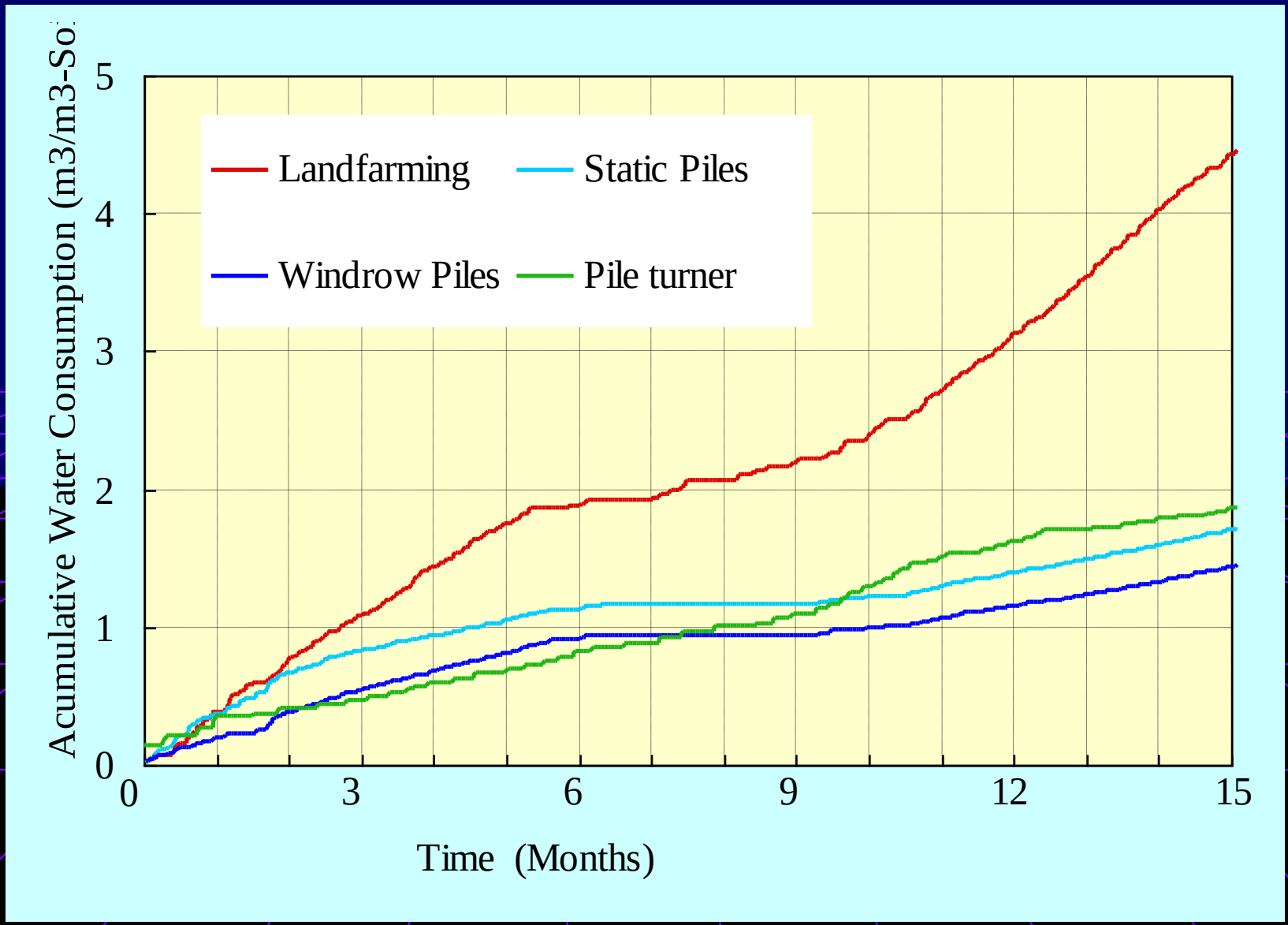
Moderately Contaminated Soil
Pile Turner Method

Name of the Strain	T=0	3 mon.	6 mon.	9 mon.	16 mon.
TA100	-	-	-	-	-
TA1535	-	-	-	-	-
WP2 uvrA	-	-	-	-	-
TA98	+	-	-	-	-
TA1537	+	-	-	-	-

Moderately Contaminated
Landfarming Method

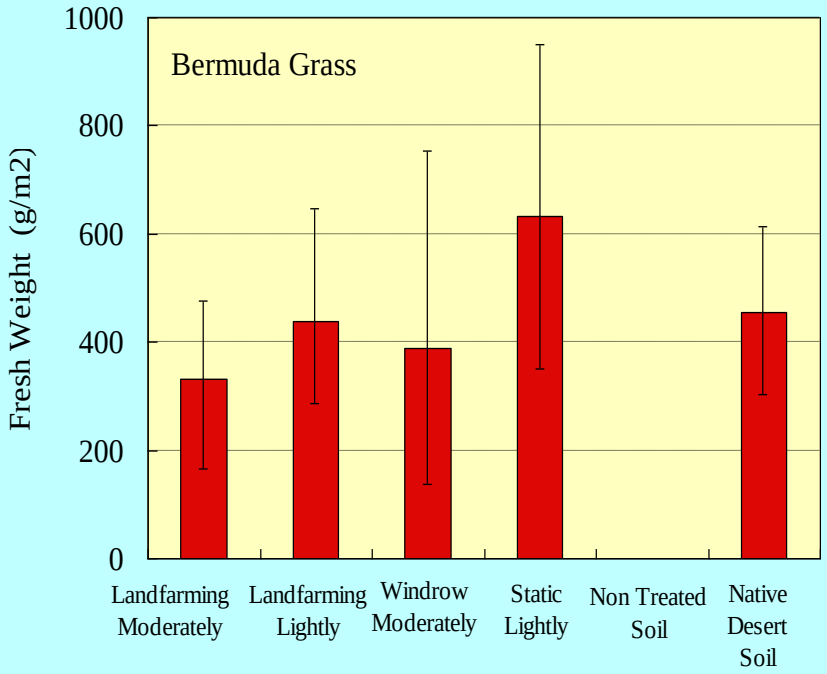
	T=0	3 mon.	6 mon.	9 mon.	16 mon.
TA100	-	-	-	-	-
TA1535	-	-	-	-	-
WP2 uvrA	-	-	-	-	-
TA98	+	-	-	-	-
TA1537	+	-	-	-	-

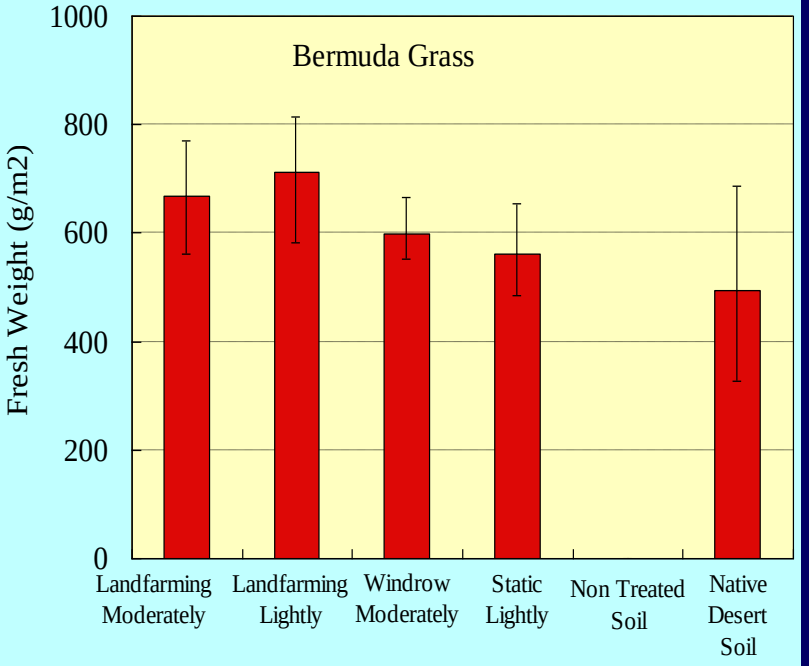
Amount of Water Requirement

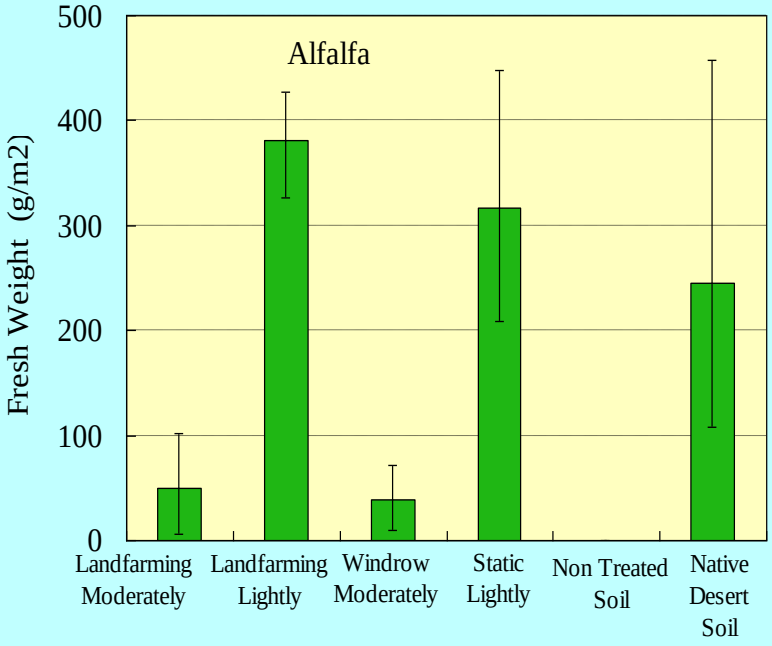


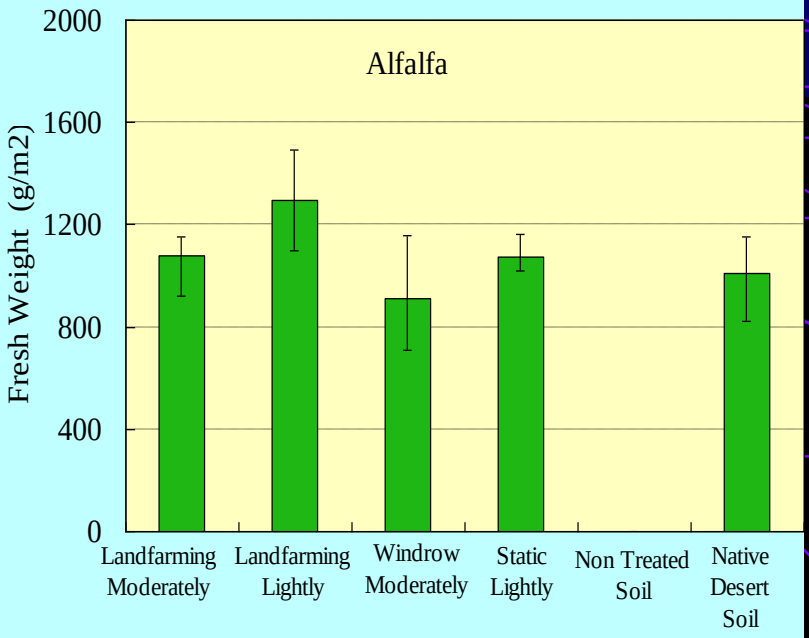
Phyto Toxicity Experiment (Alfalfa)

Measurement of the Yield (Alfalfa)


Bermuda Grass
Fresh Weight (g/m2)
1000
800
600
400
200
0
Landfarming Moderately
Landfarming Lightly
Windrow Moderately
Static Lightly
Non Treated Soil
Native Desert Soil


Bermuda Grass
Fresh Weight (g/m2)
1000
800
600
400
200
0
Landfarming Moderately
Landfarming Lightly
Windrow Moderately
Static Lightly
Non Treated Soil
Native Desert Soil


Alfalfa
Fresh Weight (g/m2)
500
400
300
200
100
0
Landfarming Moderately
Landfarming Lightly
Windrow Moderately
Static Lightly
Non Treated Soil
Native Desert Soil

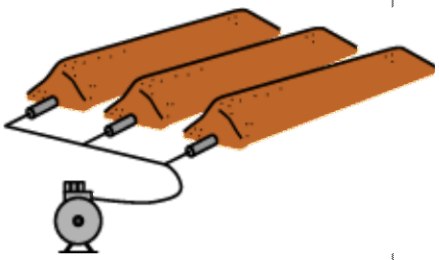
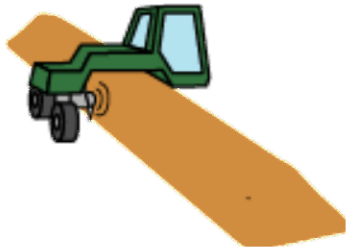

Alfalfa
Fresh Weight (g/m2)
2000
1600
1200
800
400
0
Landfarming Moderately
Landfarming Lightly
Windrow Moderately
Static Lightly
Non Treated Soil
Native Desert Soil

Large Scale Vegetation Field Experiment

The Flower Garden in the Experimental Field

The Flower Garden in the Experimental Field

Comparison of 4 Technologies

Method		Landfarming	Windrow Composting	Static Bio-venting	Pile-turner
Illustration					
		Moderately & Lightly	Moderately	Moderately & Lightly	Heavily, Moderately & Lightly
Supplying Method	Water	Rotary Irrigation System	Leaky Pipes and Top Water	Leaky Pipes and Top Water	Supplied through the Pile-turner
	Air	Tractor and Tiller	Mixing by Front Loader	Supplied from the Bottom of the Pile by Air Compressor	Supplied by the Pile-turner during Mixing
Result after 12 mo. Treatment		80% of TPH had been degraded, 40-50 % Aromatics had been degraded	70% of TPH had been degraded, 40% of Aromatics had been degraded	70% of TPH had been degraded, 50% of Aromatics had been degraded	80% of TPH had been degraded, 50 % Aromatics had been degraded
Amount of Water Sup		6 m3/m3-soil	1.4 m3/m3-soil	1.6 m3/m3-soil	1.2 - 2 m3/m3-soil
Required Equipment		Tractor and Tiller, Irrigation System	Front loader, Leaky Pipes	Compressor, Leaky Pipes	Pile-turner
Estimation	Degradation Speed	○	△	×	○
	Water Requirement	×	○	○	○

End Pont from the Each Experimental Result

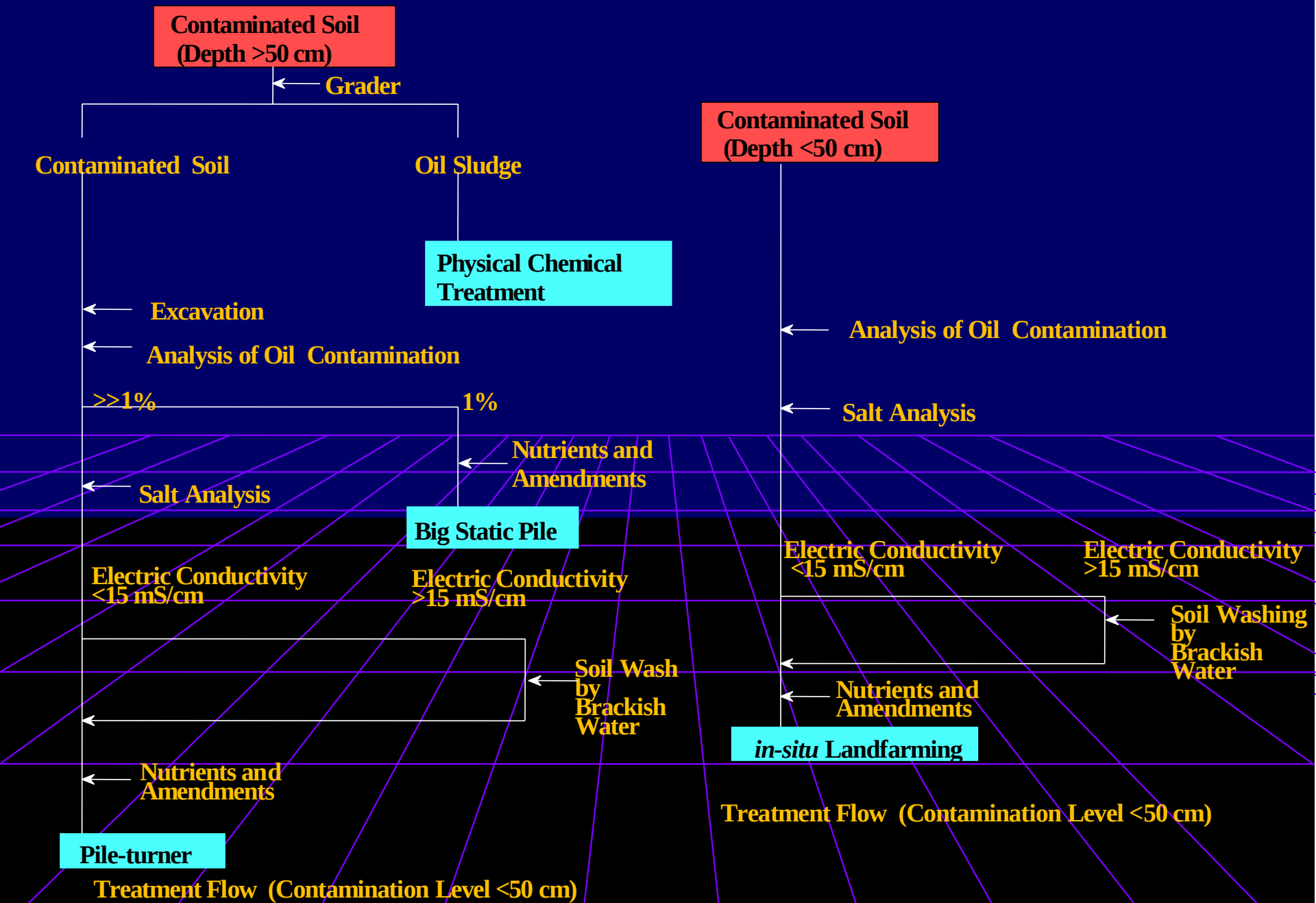
	Analytical Results	Vegetation Experiment	Mutagenicity Test
Moderately	TPH = 0.8 - 0.9% PAH = 0.5 mg/kg-soil	TPH<1%	More than Three months Treatment
Lightly	TPH = 0.2 - 0.4% PAH = 0.2 mg/kg-soil	TPH = 0.4%	More than Three months Treatment

Criteria of the Treatment

TPH<1%

(If soil TPH is under 1%, 2 to 3 months bioremediation treatment is enough to clean the soil.)

Protocol of the Treatment



Conclusion

- 15,000m3 of oil contaminated soil is bioremediated successfully.
- It was confirmed that treated soil is safe by phyto toxicity experiments and Ames tests.
- TPH<1% is proposed for the criteria of the treatment of oil contaminated soil in Kuwait.
- Pile turner technology is recommended for bioremediation and another technologies are also recommended in some cases.

Acknowledgments

- Petroleum Energy Center
- Kuwait Institute for Scientific Reseach
- Kuwait Oil Company
- Tokyo University Soil Science Lab. Honorary Prof. Matsumoto
- Tokyo University Agro-Environmental & Informatics Lab. Prof. Oyaizu
- Tokyo University Biotechnology Research Center Prof. Omori

Bioaugmentation (*Nocardia sp.*)